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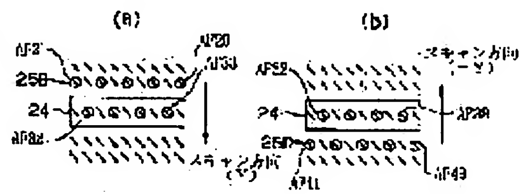
## (54) PLANE POSITION SETTING DEVICE

(57)Abstract:
PURPOSE: To align an exposure face of a photosensitive board with an image face of a projection optical system with high precision in a projection aligner using a slit-scanning exposure system.
CONSTITUTION: When a wafer is scanned being exposed in a Y-direction against a slitted exposing field 24, the leveling and focusing for the wafer are controlled based on the information on the focus positions which are obtained from the sample points AF21 to AF29 of a second row 25B on this side against the scanning direction and from the sample points AF 32 to AF38 in the field 24. On the other hand, when the wafer is scanned being exposed in a -Y-direction, the leveling and focusing are controlled based on the information on the focus positions which are obtained from the sample points AF41 to AF49 of a fourth row 25D on this side against the scanning direction and from the sample points AF32 to AF38 in the field 24.



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CLAIMS

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[Claim(s)]
[Claim 1] The illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light, and the mask side stage which scans the mask in which the pattern for exposure was formed to said lighting field, The projection optics which projects the pattern of said mask in said lighting field on a sensitization substrate, It is prepared in the aligner which has the substrate side stage which scans said sensitization substrate synchronizing with said mask. It is field location equipment for doubling the exposure side of said sensitization substrate in parallel with the image surface of said projection optics. A multipoint measurement means to measure the height of a direction parallel to the optical axis of said projection optics of said sensitization substrate in two or more measure points including two or more points of the direction which crosses in the direction in which said sensitization substrate is scanned, respectively, An operation means to ask for the difference of the tilt angle between the exposure side of said sensitization substrate, and the image surface of said projection optics from the measurement result of this multipoint measurement means, It is prepared in said substrate side stage, and is based on the difference of said tilt angle called for by said operation means. A speed of response in case it has the inclination setting stage which sets up the tilt angle of the direction which intersects perpendicularly in the tilt angle of the direction of said scan of said sensitization substrate, and the direction of said scan and this inclination setting stage sets up the tilt angle of the direction of said scan of said sensitization substrate, Field location equipment characterized by making the speed of responses when setting up the tilt angle of the direction which intersects perpendicularly towards said scan differ.
[Claim 2] Said multipoint measurement means is field location equipment according to claim 1 characterized by sampling the height of said sensitization substrate in said two or more measure points by the datum reference of said substrate side stage when said sensitization substrate is scanned through said substrate side stage.
[Claim 3] Said multipoint measurement means is field location equipment according to claim 1 or 2 characterized by measuring the height of said sensitization substrate, respectively in two or more measure points which consist of two or more points in the field of this side at the time of said sensitization substrate being scanned to the inside of two or more points in an exposure field [ **** ], and said exposure field [ **** ] about the lighting field and said projection optics of said predetermined configuration.
[Claim 4] Said multipoint measurement means is field location equipment according to claim 1 characterized by changing the location of the measure point of the sequential aforementioned plurality to one shot field of said sensitization substrate in the process which exposes the pattern of the sequential aforementioned mask.
[Claim 5] The illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light, and the mask side stage which scans the mask in which the pattern for exposure was formed to said lighting field, The projection optics which projects the pattern of said mask in said lighting field on a sensitization substrate, It is prepared in the aligner which has the substrate side stage which scans said sensitization substrate synchronizing with said mask. It is field location equipment for doubling the height of the exposure side of said sensitization substrate with the image surface of said projection optics. In the predetermined measure point in the measurement field which consists of a field of this side at the time of said sensitization substrate being scanned to an exposure field [ **** ] and this exposure field about the lighting field and said projection optics of said predetermined configuration A height measurement means to measure the height of a direction parallel to the optical axis of said projection optics of said sensitization substrate, An operation means to ask for the difference of the average height of the exposure side of said sensitization substrate, and the height of the image surface of said projection optics

based on the maximum and the minimum value of two or more height measurement results obtained by said height measurement means when said sensitization substrate is scanned, Field location equipment characterized by having the height setting stage which sets up the height of said sensitization substrate based on the difference of said height which was prepared in said substrate side stage and found by said operation means.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industry-like field of the invention] This invention is applied to the automatic focus device or auto leveling device of a projection aligner of for example, a slit scan exposure method, and relates to suitable field location equipment.
[0002]
[Description of the Prior Art] In case a semiconductor device, a liquid crystal display component, or the thin film magnetic head is manufactured at a photolithography process, the projection aligner which imprints a photo mask or the pattern of a reticle (it is hereafter named a "reticle" generically) on the substrates (a wafer, glass plate, etc.) with which it was applied to sensitization material is used. As a conventional projection aligner, each shot field of a wafer was moved into the exposure field of projection optics one by one, and many contraction projection mold aligners (stepper) of the step-and-repeat method of exposing the pattern image of a reticle one by one to each shot field were used.
[0003] Drawing 20 shows the conventional stepper's important section, in this drawing 20 , it is the basis of the exposure light EL from the illumination-light study system by which the illustration abbreviation was carried out, and projection exposure of the image of the pattern on a reticle 51 is carried out to each shot field on the wafer 53 with which the photoresist was applied through projection optics 52. A wafer 53 is held on Z leveling stage 54, and Z leveling stage 54 is laid on wafer side X-Y stage 55. Wafer side X-Y stage 55 positions a wafer 53 in a flat surface (XY flat surface) perpendicular to the optical axis AX1 of projection optics 52, and sets Z leveling stage 54 as the condition that the focal location (location of a direction parallel to an optical axis AX1) of the exposure side of a wafer 53 and the tilt angle of the exposure side were specified.
[0004] Moreover, the migration mirror 56 is being fixed on Z leveling stage 54. The laser beam from the external laser interferometer 57 is reflected in the migration mirror 56, the X coordinate and Y coordinate of wafer side X-Y stage 55 are always detected by the laser interferometer 57, and these X coordinate and Y coordinate are supplied to the main control system 58. The main control system 58 exposes the pattern image of a reticle 51 one by one to each shot field on a wafer 53 by the step-and-repeat method by controlling actuation of wafer side X-Y stage 55 and Z leveling stage 54 through a driving gear 59.
[0005] Under the present circumstances, although the pattern formation side on a reticle 51 (reticle side) and the exposure side of a wafer 53 need to be conjugate about projection optics 52, a projection scale factor is high, and since the depth of focus is large, a reticle side is seldom changed. Then, generally, by the focal location detection system of the multipoint of an oblique-incidence mold, it detected whether the exposure side of a wafer 53 would have agreed within the limits of the depth of focus in the image surface of projection optics 52 (is it focusing or not?), and the focal location of the exposure side of a wafer 53 and control of a tilt angle were performed conventionally.
[0006] In the focal location detection system of the conventional multipoint, the illumination light which does not expose the photoresist on a wafer 53 unlike the exposure light EL is drawn through the optical fiber bundle 60 from the source of the illumination light by which the illustration abbreviation was carried out. The illumination light injected from the optical fiber bundle 60 illuminates the pattern formation plate 62 through a condenser lens 61. The illumination light which penetrated the pattern formation plate 62 is projected on the exposure side of a wafer 53 through a lens 63, a mirror 64, and the exposure objective lens 65, and projection image formation of the image of the pattern on the pattern formation plate 62 is aslant carried out to the exposure side of a wafer 53 to an optical axis AX1. The illumination light reflected with the wafer 53 is re-projected on an electric eye 69 in a light-receiving side through the condensing objective

lens 66, the hand-of-cut diaphragm 67, and the image formation lens 68, and re-image formation of the image of the pattern on the pattern formation plate 62 is carried out to the light-receiving side of an electric eye 69. In this case, the main control system 58 gives vibration like the after-mentioned to the hand-of-cut diaphragm 67 through excitation equipment 70, the detecting signal from many photo detectors of an electric eye 69 is supplied to a signal processor 71, and a signal processor 71 supplies the focal signal of a large number which carried out the synchronous detection of each detecting signal, and obtained it with the driving signal of excitation equipment 70 to the main control system 58.

[0007] As drawing 21 (b) shows the opening pattern formed on the pattern formation plate 62 and shows it to this drawing 21 (b), on the pattern formation plate 62, the opening pattern 72-1 to 72-9 of the shape of nine slit is formed in the shape of a cross joint. Since those opening patterns 72-1 to 72-9 are irradiated from the direction which crosses at 45 degrees to the X-axis and a Y-axis to the exposure side of a wafer 53, each projection images AF1-AF9 of these openings pattern 72-1 to 72-9 in the exposure field of the projection optics 52 on the exposure side of a wafer 53 become arrangement as shown in drawing 21 (a). In drawing 21 </A> (a), it is inscribed in the circular lighting visual field of projection optics 52, the maximum exposure field 74 is formed, and the projection image of a slit-like opening pattern is projected on the center section in the maximum exposure field 74, and the measure points AF1-AF9 on the two diagonal lines, respectively.

[0008] As drawing 21 (c) shows the situation of the light-receiving side of an electric eye 69 and shows it to this drawing 21 (c), nine photo detectors 75-1 to 75-9 are arranged in the light-receiving side of an electric eye 69 at a cross-joint mold, and the gobo (illustration abbreviation) which has slit-like opening is arranged on each photo detector 75-1 to 75-9. And re-image formation of the image on each measure points AF [ AF1-] 9 of drawing 21 (a) is carried out on each photo detector 75-1 to 75-9 of an electric eye 69, respectively. In this case, the illumination light reflected in respect of exposure of the wafer 53 of drawing 20 (wafer side) Since it is reflected by the hand-of-cut diaphragm 67 which vibrates around a shaft almost perpendicular to the space of drawing 20 (rotational vibration) while existing in the pupil posion of the condensing objective lens 66, As shown in drawing 21 (c), on an electric eye 69, it vibrates in the direction of RD whose location of the projection image by which re-image formation is carried out on each photo detector 75-1 - 75-9 is the cross direction of slit-like opening.

[0009] Moreover, since the image of opening of the shape of a slit on each measure points AF [ AF1-] 9 of drawing 21 (a) is aslant projected to the optical axis of projection optics 52, if the focal location of the exposure side of a wafer 53 changes, the re-image formation location on the electric eye 69 of these projection images will change in the direction of RD. Therefore, nine focal signals corresponding to the focal location of measure points AF1-AF9 are acquired within a signal processor 71, respectively by carrying out the synchronous detection of the detecting signal of each photo detector 75-1 to 75-9 by the excitation signal of the hand-of-cut diaphragm 67, respectively. And from the focal location of nine pieces, the tilt angle of the average field of the exposure field 74 and the focal location of the average field are called for, the main control system 58 is supplied, and the main control system 58 sets the focal location and tilt angle (leveling angle) of the shot field concerned of a wafer 53 as a predetermined value through a driving gear 59 and Z leveling stage 54. Thus, in the stepper, in each shot field of a wafer 53, a focal location and a tilt angle are in the condition of doubling with the image surface of projection optics 52, and the pattern image of a reticle 51 was exposed, respectively.

[0010]

[Problem(s) to be Solved by the Invention] Since the pattern has made it detailed in a semiconductor device etc. in recent years, heightening the resolution of projection optics is called for. Although there is technique, such as short-wavelength-izing of the wavelength of exposure light or increase of the numerical aperture of projection optics, among the technique for heightening resolution, if it is going to secure the exposure field of same extent as the conventional example even when using which technique, it will become difficult to maintain image formation engine performance (distortion, curvature of field, etc.) for a predetermined precision all over the exposure field. Then, the so-called projection aligner of a slit scan exposure method is improved now.

[0011] In the projection aligner of this slit scan exposure method, the pattern of that reticle is exposed on a wafer, synchronizing relatively and scanning a reticle and a wafer to the shape of a rectangle, and the lighting field (henceforth a "slit-like lighting field") of circular **. Therefore, the image was equalized in the lighting field of the shape of said slit, and the field [ **** ], and there was an advantage that distortion precision improved.

[0012] Although the mainstream of the magnitude of the conventional reticle was 6 inch size and the mainstream of the projection scale factor of projection optics was 1/5 time, the magnitude of the reticle in a

basis 1/5 time the scale factor of this has stopped moreover, 6 inch size being of use with large area-ization of circuit patterns, such as a semiconductor device. Therefore, it is necessary to design the projection aligner which changed the projection scale factor of projection optics 1/4 time. And the slit scan exposure method which can make small the diameter of the exposure field of projection optics to large-area-izing of such a transferred pattern is advantageous also in a cost side.
[0013] In the projection aligner of this slit scan exposure method, since the wafer was scanned in the predetermined direction even if it applies the focal location detection system of the multipoint mold used by the conventional stepper as it is and measures the focal location and tilt angle of an exposure side on a wafer, there was un-arranging [ that it was difficult to double an actual exposure side with the image surface of projection optics ]. That is, the probability of the technique for doubling the focal location and tilt angle of a wafer with the image surface of projection optics in the projection aligner of a slit scan exposure method conventionally was not carried out.
[0014] This invention aims at offering the field location equipment which can be used in the projection aligner of a slit scan exposure method in order to double the exposure side of a sensitization substrate with high precision to the image surface of projection optics in view of this point.
[0015]
[Means for Solving the Problem] The illumination-light study system in which the 1st field location equipment of this invention illuminates the lighting field of a predetermined configuration with exposure light, The mask side stage which scans the mask (12) with which the pattern for exposure was formed to the lighting field (10), The projection optics which projects the pattern of the mask in the lighting field (12) on a sensitization substrate (5) (8), It is prepared in the aligner which has the substrate side stage (2) which scans a sensitization substrate (5) synchronizing with a mask (12). It is field location equipment for doubling the exposure side of a sensitization substrate (5) in parallel with the image surface of projection optics (8). A multipoint measurement means to measure the height of a direction parallel to the optical axis of the projection optics (8) of a sensitization substrate (5) in two or more measure points (AF11-AF59) including two or more points of the direction which crosses in the direction in which a sensitization substrate (5) is scanned, respectively (62A, 69A), It has an operation means (71A) to ask for the difference of the tilt angle between the exposure side of a sensitization substrate (5), and the image surface of projection optics (8) from the measurement result of this multipoint measurement means.
[0016] Furthermore, this invention is prepared in a substrate side stage (2), and it is based on the difference of the tilt angle called for by the operation means (71A). As it has the inclination setting stage (4) which sets up the tilt angle of the direction (the direction of X) which intersects perpendicularly in the tilt angle of the direction (the direction of Y) of the scan of a sensitization substrate (5), and the direction of the scan, for example, is shown in drawing 5 An inclination setting stage (4) is tilt-angle thetaY of the direction (the direction of Y) of the scan of a sensitization substrate (5). Tilt-angle thetaX of the direction (the direction of X) which intersects perpendicularly in the speed of response and the direction of a scan of [ when setting up ] The speed of responses when setting up are made to differ.
[0017] In this case, that multipoint measurement means may sample the height of the sensitization substrate (5) in the measure point of these plurality in the datum reference of a substrate side stage (2), when the sensitization substrate (5) is scanned through the substrate side stage (2). Moreover, the multipoint measurement means may measure the height of a sensitization substrate (5) in two or more measure points which consist of two or more points in the field of this side at the time of a sensitization substrate (5) being scanned to the inside of two or more points in an exposure field [ **** ] (24), and the exposure field [ **** ] of those about the lighting field and projection optics (8) of the predetermined configuration, respectively.
[0018] Moreover, as for the multipoint measurement means, it is desirable to change the location of the measure point of these plurality to one shot field of a sensitization substrate (5) one by one in the process which exposes the pattern of a mask (12) one by one. Moreover, the 2nd field location equipment by this invention The mask side stage which scans the mask (12) with which the pattern for exposure was formed to the lighting field with the illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light (10), The projection optics which projects the pattern of the mask in the lighting field (12) on a sensitization substrate (5) (8), It is prepared in the aligner which has the substrate side stage (2) which scans a sensitization substrate (5) synchronizing with a mask (12). It is field location equipment for doubling the height of the exposure side of a sensitization substrate (5) with the image surface of projection optics (8). In the predetermined measure point in the measurement field which consists of a field of this side at the time of a sensitization substrate (5) being scanned to an exposure field [ **** ] (24) and this exposure field about the lighting field and projection optics (8) of that predetermined

configuration A height measurement means to measure the height of a direction parallel to the optical axis of the projection optics (8) of a sensitization substrate (5) (62A, 69A), The inside of two or more height measurement results obtained by the height measurement means when a sensitization substrate (5) is scanned, An operation means to ask for the difference of the average height of the exposure side of a sensitization substrate (5), and the height of the image surface of projection optics (8) based on maximum and the minimum value (71A), It is prepared in a substrate side stage (2), and has the height setting stage (4) which sets up the height of a sensitization substrate (5) based on the difference of the height found by the operation means (71A).

[0019]

[Function] In the 1st field location equipment of this this invention, in case a mask (12) and a sensitization substrate (5) are scanned synchronously and the pattern image of a mask (12) is exposed on a sensitization substrate (5), the height of a sensitization substrate (5) is measured using the multipoint measurement means in two or more measure points containing the measure point before the direction of the scan. And it asks for the tilt angle of a sensitization substrate (5) by acquiring multiple-times height information along the direction of a scan, respectively in the measure point of these plurality. Then, in case the pattern image of a mask (12) is exposed to the field to which the tilt angle was called for such, the tilt angle of the field is set up based on the tilt angle for which it asked beforehand. Thereby, the exposure side of a sensitization substrate (5) is set up in parallel with the image surface of projection optics (8) also by the slit scan exposure method.

[0020] Moreover, in this invention, in case such leveling is performed, the speed of response of leveling of the scanning direction differs from the speed of response of the non-scanning direction leveling. In order to explain per [ by this ] operation effectiveness, focusing at the time of slit scan exposure and the error factor of leveling are explained. The following errors can be considered with the aligner of a slit scan exposure method.

** A focal offset error and an oscillating error focus offset error are differences of the focal location of the average field of an exposure side, and the image surface of projection optics, and an oscillating error is an error resulting from vibration of the direction of a focus of the substrate side stage at the time of carrying out scan exposure etc. It divides, when carrying out one-shot exposure like a stepper as what performs only automatic focus control, and when exposing by the slit scan exposure method, and this is explained more to a detail.

[0021] When carrying out one-shot exposure of drawing 14 (a), it shows the case where drawing 14 (b) is exposed by the slit scan exposure method. although the average field 34 of exposure side 5a of a sensitization substrate has agreed in the image surface of projection optics in drawing 14 (a) -- the average field 34 where the focal location of locations Ya, Yb, and Yc is fixed respectively -- receiving -deltaZ -- 1 and 0 differ only from deltaZ2. Therefore, the focal offset errors in locations Ya and Yb are -deltaZ1 and deltaZ2, respectively.

[0022] On the other hand, in the case of drawing 14 (b), a series of partial average sides 35A, 35B, and 35C on exposure side 5a and .... double one by one to the scanning direction in the image surface of projection optics. Therefore, the focal offset error in each locations Ya, Yb, and Yc is set to 0 by the equalization effectiveness, respectively. However, although the image on a location Yb is formed, since a focal location moves between height deltaZB(s) from average side 35B to average side 35D, the image on a location Yb will turn into an image with which only delta ZB had dispersion in the direction of a focus. Similarly, the image on a location Ya and Yc turns into an image with which only delta ZA and delta ZB had dispersion in the direction of a focus, respectively.

[0023] That is, in a slit scan exposure method, although a focal offset error is set to about 0 to the irregularity of the sensitization substrate side below a certain constant frequency, the wavelength variation of the short period of rolling of a substrate side stage, pitching, vibration of the direction of a focus (Z shaft orientations), the error component by an automatic focus device and an auto leveling device following a low frequency air fluctuation error, and exposure light (KrF excimer laser light etc.) etc. produces a new error (oscillating error).

[0024] ** Although it is a typical example of a focal following error, an air fluctuation error, and the oscillating errors that made reference by stage oscillating error ** and these are dependent on the response frequency of an automatic focus device and an auto leveling device, it can classify into the following errors further.

(1) (2), such as a high-frequency stage oscillating error, a wavelength-variation error of the short period of exposure light (KrF excimer laser light etc.), etc. uncontrollable by the control system, (3), such as a low-

frequency air fluctuation error which a substrate side stage follows in an air fluctuation error Measurement error which does not turn into a focal error since a substrate side stage does not follow, although contained in the measurement result of a focal location detection system or a tilt-angle detection system.
[0025] ** a field unit with the two-dimensional exposure field according [ the error of ****** by unevenness of the exposure side of a sensitization substrate ] to projection optics -- it is -- measurement of the focal location in the exposure side of a sensitization substrate -- the measure point of a finite individual -- and it is an error resulting from carrying out at the time of slit scan exposure, and can classify into the following two errors.
(1) For example, originate in the operation approach for the location of the measure point in the case of measuring a focal location by the multipoint on exposure side 5a of a sensitization substrate, and searching for the fields 36A and 36B for alignment (focal field), as shown in drawing 15 (a) and (b). The error of the gap with the focal side 36A and an ideal focus side, and (2) Error by the difference with the slew rate of scan speed, an automatic focus device, and an auto leveling device, the speed of response of a focal location detection system, etc.
[0026] In this case, the speed of response in the case of doubling a focal location with the image surface of projection optics (focal response) is determined by a time lag error as shown in drawing 15 (c), and servo gain as shown in drawing 15 (d). That is, in drawing 15 (c), curvilinear 37A shows the driving signal for the directions of a focus for doubling a series of subregions of exposure side 5a of a sensitization substrate with the image surface of projection optics one by one (target focus position signal), and curvilinear 38A shows the signal (flattery focus position signal) which converted the movement magnitude to the direction of a focus of a series of subregions of exposure side 5a into the driving signal, and was acquired. Only fixed time amount is behind in curvilinear 38A to curvilinear 37A. Similarly, in drawing 15 (d), the target focus position signal of a series of subregions of exposure side 5a of a sensitization substrate and curvilinear 38B of curvilinear 37B are the flattery focus position signals of a series of subregions of exposure side 5a, and, as for the amplitude (servo gain) of curvilinear 38B, only the constant rate is small to curvilinear 37B.
[0027] With the 1st field location equipment of this invention, in order to remove these errors, the responsibility of the scanning direction of a leveling device and the responsibility of the non-scanning direction are changed. It is premised on the focal location detection system of the multipoint of an oblique incidence mold as a multipoint measurement means for auto leveling devices in this invention. Moreover, it aims at making maximum of the gap with each point of the exposure side in the predetermined field, and the image surface of projection optics into min regardless of the average field of the exposure side of the sensitization substrate in the predetermined field in the exposure field of projection optics. Thus, in the predetermined field in the exposure field of projection optics, the exposure field in case the maximum of the gap with almost all the points of the exposure side of a sensitization substrate and the image surface of projection optics is min is called "the good field (Good Field)."
[0028] First, as shown in drawing 16 , it is assumed that many measure points (un-illustrating) of a focal location are in the exposure field 24 of the shape of a slit [ **** ] about slit-like a lighting field and projection optics. In drawing 16 , width of face of the scanning direction of WX and the exposure field 24 is set [ the width of face of the scanning direction of the shot field SAij ] to D for the width of face of WY and the non-scanning direction as what scans one shot field SAij on a sensitization substrate by rate V/beta in the direction of Y to the slit-like exposure field 24. Moreover, by equalizing the focal location in many measure points in central field 24a in the exposure field 24 It asks for the focal location of the average field in the central point of the exposure field 24. It is based on the least squares approximation from the focal location in the measure point in measurement field 24b of the both ends of the scanning direction of the exposure field 24, and 24c, and is tilt-angle thetaY of the scanning direction of an average field. It asks. It is based on the least squares approximation from the focal location in the measure point in measurement field 24b of the both ends of the non-scanning direction of the exposure field 24, and 24c, and is tilt-angle thetaX of the non-scanning direction of an average field. It shall ask. Moreover, the value of fm and fn is set up independently, using the response frequency of leveling of fm [Hz] and the non-scanning direction as fn [Hz] for the response frequency of leveling of the scanning direction.
[0029] And the period of the periodic deflection of the scanning direction of the shot field SAij on a sensitization substrate Bend as a value of a ratio with the width of face WY (the non-scanning direction is also set as the same deflection period) of the scanning direction, and it expresses with Parameter F. The focal error in each measure point in the exposure field 24 in case there is the periodic deflection is expressed with the absolute value of the average of the focal error at the time of scanning, and one third of the sums of the amplitude of the focal error at the time of scanning. Moreover, the amplitude of the periodic deflection

of the deflection parameter F is standardized to 1, and the error parameter S which shows the maximum of the focal errors in each [ these ] measure point in case a deflection parameter is F is expressed as a ratio to the deflection parameter F. That is, the degree type is materialized.
The period of F= deflection / WY (1)
The maximum/F of S= focus error (2)
[0030] Drawing 17 (a) expresses the error parameter S to the deflection parameter F when the response frequency fm of leveling of the scanning direction and the response frequency fn of leveling of the non-scanning direction are equal and large. A curve A1 The absolute value of the average of a focal error usual [ in the error parameter S of the non-scanning direction ] in the error parameter S and curve B1 in the non-scanning direction, A curve A2 shows the average of a focal error usual [ in the error parameter S of the scanning direction ] in the error parameter S and curvilinear B-2 in the scanning direction. The curve A1 and the curve A2 express the respectively more realistic focal error. When [ when the value of Meter F is small ] the period of the irregularity of an exposure side is small, as for the flattery nature of leveling control of the scanning direction, it turns out that leveling control of the scanning direction comes to follow deflection bad (curve A2) as a concavo-convex period becomes large. Moreover, since a focal location does not change serially like the scanning direction to the non-scanning direction, even if the period of deflection becomes large, it is worse than the flattery nature of the scanning direction (curve A1). As mentioned above, although it is desirable for a focal error to become so that Parameter S may become 0.5 or less, the scanning direction and the non-scanning direction of a focal error are large as a whole.
[0031] On the other hand, the response frequency fm of drawing 17 (b) of leveling of the scanning direction is larger than the response frequency fn of leveling of the non-scanning direction. And the error parameter S to the deflection parameter F when both the response frequencies fm and fn are small is expressed. As for the absolute value of the average of the focal error of the non-scanning direction usual in the error parameter S and curve B3 in the non-scanning direction, and curvilinear A4, curvilinear A3 shows the absolute value of the average of the usual focal error in the scanning direction, as for the error parameter S and curvilinear B4 in the scanning direction. The comparison with drawing 17 (a) and drawing 17 (b) shows that the direction when a response frequency is almost smaller than the case of a full response ( drawing 17 (a)) ( drawing 17 (b)) is close to 0.5, and a focal error has [ the error parameter S ] it. [ small ] This is for the fine point on a sensitization substrate that precision will get worse in the slit-like exposure field 24 if an auto leveling device follows unevenly to occur. However, since it becomes impossible to follow to the uneven section of low frequency when a response frequency is made small too much, it is necessary to set a response frequency as a suitable value.
[0032] Moreover, in the example of drawing 17 (b), the response frequency fm of leveling of the scanning direction is set up more highly than the response frequency fn of leveling of the non-scanning direction. Even if this is the irregularity of the same deflection parameter F, since a period becomes short substantially according to slit width, in the scanning direction, the response frequency for following the irregularity of an exposure side good is because it is necessary to make it higher in the scanning direction than the non-scanning direction.
[0033] Moreover, it sets at two or more measure points when the multipoint measurement means for auto leveling devices becomes from two or more points in the field of this side at the time of a sensitization substrate (5) being scanned to the inside of two or more points in an exposure field [ **** ] (24), and the exposure field [ **** ] of those about the lighting field and projection optics (8) of the predetermined configuration. When measuring the height of a sensitization substrate (5), respectively, in a front measure point, a read ahead of a focal location is performed partially. This is called "a division read ahead." Therefore, compared with the technique (full read ahead) of predicting in all measure points, the die length at the time of reading a focal location with a multipoint measurement means by exposure (inlet length) is shortened.
[0034] Moreover, when the multipoint measurement means changes the location of the measure point of these plurality to one shot field of a sensitization substrate (5) one by one in the process which exposes the pattern of a mask (12) one by one, for example at the edge of the shot field, a division read ahead is performed, henceforth [ the center section of the shot field ], a full read ahead is performed and opening control is checked by the exposure location detecting element. Thereby, where leveling precision is maintained with high precision, the inlet length in the edge of a shot field can be shortened, and the throughput of exposure can be raised.
[0035] Next, the automatic focus control in the 2nd field location equipment of this invention is considered. If the concept of the above-mentioned good field (Good Field) is taken in, as shown in drawing 16 ,

precision may get worse by performing equalization processing of the focal location of each measure point in center-section 24a of the exposure field 24, and doubling with the image surface of projection optics the field shown by the average of the focal location. That is, drawing 18 (a) shows field 34A corresponding to the average of the focal location of each measure point of exposure side 5a with the crevice of depth H of a sensitization substrate, and the difference deltaZ3 of the direction of a focus of the field 34A and crevice is large from H/2.

[0036] On the other hand, in this invention, the maximum and the minimum value of a focal location of each measure point in a measurement field predetermined [ on exposure side 5a ] are calculated, and the field corresponding to the middle focal location of these maximums and the minimum value is doubled with the image surface of projection optics. Drawing 18 (b) is the maximum Zmax of the focal locations of each measure point in exposure side 5a with the crevice of depth H of a sensitization substrate. Minimum value Zmin Field 34B corresponding to a middle focal location is shown, and it is focal location Z34of field 34B B. It can express as follows.

Z34B =(Zmax +Zmin )/2 (3)

[0037] Then, the field 34B doubles with the image surface of projection optics. Moreover, the difference deltaZ4 of the direction of a focus of field 34B and the front face of exposure side 5a and about H/of differences deltaZ5 of the direction of a focus of field 34B and its crevice are 2, respectively. That is, since the direction of field 34B of drawing 18 (b) becomes [ the maximum of the error of the focal location in each point on exposure side 5a ] small compared with field 34A of drawing 18 (a), on the concept of the good field (Good Field), the exposure side of a sensitization substrate can be doubled more with high degree of accuracy by this invention in the image surface of projection optics.

[0038] Furthermore, the property of the error parameter S over the deflection parameter F at the time of performing automatic focus control based on equalization processing of drawing 18 (a) or automatic focus control based on the average of the maximum of drawing 18 (b) and the minimum value is shown in drawing 19 (a), and (b), respectively at the same time it makes the response frequency fm of leveling of the scanning direction, and the response frequency fn of leveling of the non-scanning direction equally and large and performs auto leveling control like drawing 17 (a). That is, in curvilinear A5 and B5, in drawing 19 (a) based on equalization processing, the error parameter S, the curve A6, and B6 of the non-scanning direction express the error parameter S of the scanning direction, respectively. Moreover, in drawing 19 (b) based on the average of maximum and the minimum value, curves A7 and B7 express the error parameter S of the non-scanning direction, and curves A8 and B8 express the error parameter S of the scanning direction, respectively.

[0039] When automatic focus control is performed like [ it is ****** and ] based on the average of maximum and the minimum value from drawing 19 (b), while the value of the error parameter S is close to 0.5 in all the deflection parameters F, i.e., all frequency bands, compared with the case where automatic focus control is performed based on equalization processing, the maximum of a focal error is small.

[0040] Moreover, when only automatic focus control is performed to drawing 15 (a) and (b) based on the average of the maximum of a focal location and the minimum value which were obtained in the measure point in return and a predetermined measurement field, as shown in drawing 15 (a), field 36A of deltaZa doubles with the image surface of projection optics in the difference of a focal location with maximum to exposure side 5a which has the deflection of amplitude 2 and deltaZa. On the other hand, while performing automatic focus control based on the average of the focal location only obtained in these measure points to exposure side 5a which has the deflection of amplitude 2 and deltaZa If auto leveling control is performed based on the least squares approximation of the obtained focal location, as shown in drawing 15 (b) Field 36B of deltaZb (>deltaZa) may double with the image surface of projection optics in the difference of the focal location from maximum within the limits of amplitude deltaZc (>2 and deltaZa). Therefore, a focal error becomes [ the direction which performs automatic focus control based on the average of the maximum of a focal location and the minimum value which were obtained ] small, when using an auto leveling device, or even when not using it.

[0041] In addition, although it is controlling by this invention to double with the image surface the field which becomes settled in the (minimum value Zmin of the maximum Zmax+ focus location of a focal location) / 2, depending on a device process, which the depth of focus of the heights of exposure side 5a of a sensitization substrate or a crevice may be required. Therefore, it is desirable to perform control which doubles with the image surface the field of the focal location ZMN which becomes settled in proportional distribution like a degree type using the predetermined multipliers M and N.

ZMN=(M-Zmax+N-Zmin)/(M+N) (4)

[0042]
[Example] Hereafter, with reference to a drawing, it explains per example of this invention. This example applies this invention to the automatic focus device and auto leveling device of a projection aligner of a slit scan exposure method. Drawing 1 shows the projection aligner of this example, the pattern on a reticle 12 is illuminated by the lighting field (henceforth a "slit-like lighting field") of the rectangle by the exposure light EL from the illumination-light study system by which the illustration abbreviation was carried out in this drawing 1 , and projection exposure of the image of that pattern is carried out on a wafer 5 through projection optics 8. Under the present circumstances, synchronizing with a reticle 12 being scanned with constant speed V in the direction of this side (or other side) to the space of drawing 1 , a wafer 5 is scanned by the other side (or the direction of this side) to the space of drawing 1 to the lighting field of the shape of a slit of the exposure light EL by constant speed V/beta (1/beta is the contraction scale factor of projection optics 8).
[0043] The reticle Y drive stage 10 which can be freely driven to Y shaft orientations (direction perpendicular to the space of drawing 1 ) on the reticle susceptor 9 is laid by explaining the drive system of a reticle 12 and a wafer 5, the reticle minute drive stage 11 is laid on this reticle Y drive stage 10, and the reticle 12 is held by the vacuum chuck etc. on the reticle minute drive stage 11. As for the reticle minute drive stage 11, only a minute amount performs position control of a reticle 12 to the direction of X parallel to space, the direction of Y, and hand of cut (the direction of theta) of drawing 1 with high precision in a field perpendicular to the optical axis of projection optics 8, respectively. It always acts as the monitor of the location of the direction of X of the reticle minute drive stage 11, the direction of Y, and the direction of theta with the interferometer 14 which the migration mirror 21 has been arranged on the reticle minute drive stage 11, and has been arranged on the reticle susceptor 9. The positional information S1 acquired by the interferometer 14 is supplied to main control system 22A.
[0044] On the other hand on the wafer susceptor 1, the wafer Y-axis drive stage 2 which can be freely driven to Y shaft orientations is laid, the wafer X-axis drive stage 3 which can be freely driven to X shaft orientations is laid on it, Z leveling stage 4 is formed on it, and the wafer 5 is held by vacuum adsorption on this Z leveling stage 4. The migration mirror 7 is fixed also on Z leveling stage 4, it acts as the monitor of the location of the direction of X of Z leveling stage 4, the direction of Y, and the direction of theta with the interferometer 13 arranged outside, and the positional information acquired by the interferometer 13 is also supplied to main control system 22A. Main control system 22A controls actuation of the whole equipment while controlling positioning actuation of the wafer Y-axis drive stage 2, the wafer X-axis drive stage 3, and Z leveling stage 4 through wafer driving gear 22B etc.
[0045] Moreover, in order to take correspondence of the wafer system of coordinates specified by the coordinate measured by the interferometer 13 by the side of a wafer, and the reticle system of coordinates specified by the coordinate measured by the interferometer 14 by the side of a reticle, the reference mark plate 6 is being fixed near the wafer 5 on Z leveling stage 4. Various reference marks are formed on this reference mark plate 6. In these reference marks, the reference mark currently illuminated from the background by the illumination light led to Z leveling stage 4 side, i.e., a luminescent reference mark, is prepared.
[0046] The reticle alignment microscopes 19 and 20 for observing the reference mark on the reference mark plate 6 and the mark on a reticle 12 to coincidence are equipped above the reticle 12 of this example. In this case, if the deviation mirrors 15 and 16 for leading the detection light from a reticle 12 to the reticle alignment microscopes 19 and 20, respectively are arranged free [ migration ] and an exposure sequence is started, the deviation mirrors 15 and 16 will shunt with the mirror driving gears 17 and 18 under the command from main control system 22A, respectively.
[0047] It equips with the multipoint focus location detection system of the oblique-incidence mold of the conventional method explained to the projection aligner of the slit scan method of drawing 1 with reference to drawing 20 and drawing 21 . However, while the multipoint focus location detection system of this example has more number of a measure point than the conventional example, arrangement of a measure point is devised. As drawing 2 (b) shows pattern formation plate 62A of this example corresponding to the conventional pattern formation plate 62 of drawing 21 (b) and shows it to drawing 2 (b) The opening pattern 72-11 to 72-19 of the shape of nine slit is formed in eye the 1st train of pattern formation plate 62A, and nine opening patterns 72-12 to 72-59 are formed also in eye the 5th train [ eye the 2nd train - ], respectively. That is, the opening pattern of the shape of 45 slit is formed in pattern formation plate 62A in total, and the image of the opening pattern of the shape of these slit is aslant projected to the X-axis and a Y-axis on the exposure side of the wafer 5 of drawing 1 .

[0048] Drawing 2 (a) shows the exposure side of the wafer 5 of the lower part of the projection optics 8 of this example, the pattern of the reticle 12 of drawing 1 is exposed in this drawing 2 (a) in the exposure field 24 of a rectangle long in the direction of X inscribed in the circular lighting visual field 23 of projection optics 8, and a wafer 5 is scanned in the direction of Y to this exposure field 24 (scan). By the multipoint focus location detection system of this example Nine measure points AF11-AF19 of the 1st train extended in the direction of X of the direction top of Y of the exposure field 24, The measure points AF21-AF29 of the 2nd train, The image of a slit-like opening pattern is projected on the measure points AF31-AF39 of the 3rd train in the exposure field 24, the measure points AF41-AF49 of the 4th train of the direction bottom of Y of the exposure field 24, and the measure points AF51-AF59 of the 5th train, respectively.
[0049] Drawing 2 (c) shows electric-eye 69A of the multipoint focus location detection system of this example, nine photo detectors 75-11 to 75-19 are arranged on this electric-eye 69A at eye the 1st train, and nine photo detectors 75-12 to 75-59 are arranged also at eye the 5th train [ eye the 2nd train - ], respectively. That is, 45 photo detectors are arranged in total by electric-eye 69A, and slit-like drawing (illustration abbreviation) is arranged on each photo detector. Moreover, re-image formation of the image of the opening pattern of the shape of a slit projected at the measure points AF11-AF59 of drawing 2 (a), respectively on these photo detector 75-11 - 75 -59 is carried out. And on electric-eye 69A, it vibrates in the direction of RD whose location of each image by which re-image formation was carried out is the cross direction of a diaphragm by carrying out rotational vibration of the light reflected in respect of exposure of a wafer 5 with the diaphragm corresponding to the hand-of-cut diaphragm 67 of drawing 20 .
[0050] When the detecting signal of each photo detector 75-11 to 75-59 is supplied to signal processor 71A and carries out the synchronous detection of each detecting signal by the signal of a rotational-vibration frequency in signal treatment equipment 71A Like [ 45 focal signals corresponding to the focal location of each measure points AF11-AF59 on a wafer are generated, and / signal / of these 45 focal signals / predetermined / focal ] the after-mentioned The tilt angle (leveling angle) and the average focal location of an exposure side of a wafer are computed. The leveling angle and the focal location which were these-measured are supplied to main control system 22A of drawing 1 , and main control system 22A performs the leveling angle of a wafer 5, and a setup of a focal location through driving gear 22B and Z leveling stage 4 based on the leveling angle and focal location which were supplied.
[0051] Therefore, in this example, the focal location of all 45 measure points AF11-AF59 shown in drawing 2 (a) is measurable. However, in this example, as shown in drawing 3 , the location of the point (henceforth a "sample point") which actually measures a focal location in these 45 measure points according to the scanning direction of a wafer is changed. When scanning a wafer in the direction of Y to the exposure field 24, and in performing a division read ahead like the after-mentioned as an example as shown in drawing 3 (a), the odd-numbered measure points AF21, AF23, ...., AF29 in the measure point of 2nd train 25B and the even-numbered measure points AF32, AF34, .., AF38 in the exposure field 24 turn into a sample point. Moreover, when scanning a wafer in the direction of -Y to the exposure field 24, and in performing a division read ahead like the after-mentioned as shown in drawing 3 (b), the odd-numbered measure points AF41, AF43, ...., AF49 in the measure point of 4th train 25D and the even-numbered measure points AF32, AF34, .., AF38 in the exposure field 24 turn into a sample point.
[0052] Furthermore, since the measurement result of the focal location at the time of slit scan exposure changes serially according to the migration coordinate of the stage by the side of a wafer, the measurement result of these focus location is memorized by the storage in main control system 22A of drawing 1 as a two-dimensional map which consists of a coordinate of the scanning direction of a stage, and a coordinate of the measure point of the non-scanning direction. Thus, the focal location and leveling angle of a wafer at the time of exposure are computed using the memorized measurement result. And when actually driving Z leveling stage 4 of drawing 1 and setting up the focal location and leveling angle of an exposure side of a wafer, actuation of Z leveling stage 4 is controlled by open loop control according to a measurement result. In this case, exposure in the exposure field 24 is performed based on the result measured beforehand. That is, as shown in drawing 4 (a), measurement of the focal location of the field 26 on a wafer is performed by the predetermined sampling point of the measure point of 2nd train 25B, and as shown in drawing 4 (b) after that, when the field 26 on a wafer reaches in the exposure field 24, based on the measurement result in drawing 4 (a), focusing of the field 26 on a wafer and leveling control are performed.
[0053] Drawing 5 shows Z leveling stage 4 and this control system of this example, the top-face member of Z leveling stage 4 is supported through the three supporting points 28A-28C in this drawing 5 on the inferior-surface-of-tongue member, and each supporting points 28A-28C can be expanded now and contracted in the direction of a focus, respectively. adjusting the amount of telescopic motion of each

supporting points 28A-28C -- tilt-angle thetaY of the focal location of the exposure side of the wafer 5 on Z leveling stage 4, and the scanning direction And tilt-angle thetaX of the non-scanning direction It can be set as a desired value. Near each supporting points 28A-28C, the amount of displacement of the direction of a focus of each supporting point is attached in the height sensors 29A-29C measurable with the resolution of about 0.01 micrometers, respectively. In addition, the highly precise device in which a stroke is more long as a positioning device to the direction of a focus (Z direction) may be established independently.
[0054] tilt-angle thetaX which looks like [ the filter sections 30A and 30B ] main control system 22A every moment, respectively, and changes in order to control leveling actuation of Z leveling stage 4 and which should set up the non-scanning direction And tilt-angle thetaY which should set up the scanning direction It supplies. The filter sections 30A and 30B supply the tilt angle filtered and obtained by filter shape different, respectively to operation part 31, and main control system 22A supplies the coordinate W of the field made applicable [ on a wafer 5 ] to exposure (X, Y) to operation part 31. Operation part 31 supplies the information on the amount of displacement which should be set as mechanical components 32A-32C based on Coordinate W (X, Y) and two tilt angles. The information on the current height of the supporting points 29A-29C is also supplied to each mechanical components 32A-32C from the height sensors 29A-29C, respectively, and each mechanical components 32A-32C set the height of the supporting points 29A-29C as the height set as operation part 31, respectively.
[0055] Thereby, although the tilt angle of the scanning direction of the exposure side of a wafer 5 and the tilt angle of the non-scanning direction are set as a desired value, respectively, the response frequency fm of leveling of the scanning direction [Hz] is more highly set up by the difference of the property of the filter sections 30A and 30B from the speed of response fn of leveling of the non-scanning direction [Hz] in this case. The speed of response fn of leveling of 10Hz and the non-scanning direction of the response frequency fm of leveling of the scanning direction is 2Hz as an example.
[0056] Moreover, if the location where the supporting points 28A, 28B, and 28C are arranged is called the driving points TL1, TL2, and TL3, respectively, the driving points TL1 and TL2 are arranged on 1 straight line parallel to a Y-axis, and the driving point TL 3 is located on perpendicular 2 bisectrix with the driving points TL1 and TL2. And if the exposure field 24 of the shape of a slit by projection optics shall be located on the shot field SAij on a wafer 5, in case it will perform leveling control of a wafer 5 through the supporting points 28A-28C in this example, the focal location of the shot field SAij does not change. Therefore, it is carried out in the form which leveling control and focal control separated. Moreover, a setup of the focal location of the exposure side of a wafer 5 is performed when only the same amount carries out the variation rate of the three supporting points 28A-28C.
[0057] Next, it explains to a detail per leveling actuation of this example, and focusing actuation. First, the method of computing the tilt angle for leveling and the focal location for focusing is shown.
(A) it is shown in computing method drawing 4 of a tilt angle -- as -- the measure point of each train -- setting -- the X coordinate of the m-th sample point of the non-scanning direction -- the Y coordinate of the n-th sample point of Xm and the scanning direction -- Yn ** -- carrying out -- X coordinate Xm And Y coordinate Yn The value of the focal location measured at the sample point is expressed with AF (Xm and Yn). Moreover, the next operation is performed, using the number of samplings of M and the scanning direction as N for the measurement size of the non-scanning direction. However, sum operation sigmam The sum to 1-M about Subscript m is expressed.
[0058]
SX=sigma m Xm, SX2=sigmam Xm2, SMZ=sigma m AF (Xm and Yn) SXZ=sigmam (AF (Xm and Yn) and Xm) (5)
Similarly, it is sum operation sigman. The next operation is performed as a thing showing the sum to 1 about Subscript n - N.
SY=sigma n Yn, SY2=sigman Yn2, SNZ=sigma n AF (Xm and Yn) SYZ=sigman (AF (Xm and Yn) and Yn) (6)
[0059] And the next operation is performed using (5) types and (6) types.
An=(SX-SMZ-M-SXZ)/(SX2-M-SX2) (7)
Am=(SY-SNZ-N-SYZ)/(SY2-N-SY2) (8)
next, every -- the tilt angle AL (Yn) of the non-scanning direction [ in / by the least squares approximation / from An / the n-th sample point of the scanning direction ] (the direction of X) -- asking -- every -- it asks for the tilt angle AL (Xm) of the scanning direction (the direction of Y) in the m-th sample point of the non-scanning direction by the least squares approximation from Am. Then, it is tilt-angle thetaX of the non-scanning direction by the following equalization processings. And tilt-angle thetaY of the scanning direction

It asks.
thetaX = (sigman AL (Yn)) / N (9)
thetaY = (sigmam AL (Xm)) (10)
[0060] (B) There are an equalization approach and the maximum minimum detecting method as method of computing the focal location computing method focus location, and compute a focal location by the maximum minimum detecting method in this example. With an equalization approach, the focal location <AF> as the whole exposure side of a wafer 5 is calculated from a degree type using the value AF of an above-mentioned focal location (Xm and Yn) for reference.
<AF> =(sigman sigmam AF (Xm and Yn))/(M-N) (11)
[0061] Next, focal location AF' as the whole exposure side of a wafer 5 is calculated from a degree type by setting to Max ( ) and Min ( ) the function which expresses maximum and the minimum value with the maximum minimum detecting method, respectively.
AF'= (Max(AF (Xm and Yn)) +Min(AF (Xm and Yn)) /2 (12))
and -- the time of the measured field 26 arriving at the exposure field 24, as shown in drawing 4 (b) -- detection result thetaX of (9) types, (10) types, and (12) types, and thetaY And based on AF', the three supporting points 28A-28C of drawing 5 drive with open-loop on the basis of the measurement result of the height sensors 29A-29C, respectively. Concretely, automatic focus control is performed by driving the three supporting points 28A-28C to coincidence, and auto leveling control is performed so that the focal location in the exposure field 24 shown in drawing 5 may not change.
[0062] In drawing 5 spacing of the direction of X of the central point of the exposure field 24, and the supporting points 28A and 28B Namely, X1, They are the central point of Y1 and the exposure field 24, and spacing of the direction of Y of supporting-point 28B about the central point of X2 and the exposure field 24, and spacing of the direction of Y of supporting-point 28A in the central point of the exposure field 24, and spacing of the direction of X of supporting-point 28C Y2 It carries out. Tilt-angle thetaX of the non-scanning direction It is based on a result and is X1, respectively to the supporting points 28A and 28B and supporting-point 28C. : X2 The variation rate of hard flow is given by the ratio. Tilt-angle thetaY of the scanning direction It is based on a result and is Y1 to supporting-point 28A and supporting-point 28B, respectively. : Y2 The variation rate of hard flow is given by the ratio.
[0063] Moreover, in the above-mentioned approach, since a focal location and a tilt angle change every moment according to an aligner, it is necessary to amend the measurement value of an actual focal location. Drawing 6 (a) shows the condition are measuring the focal location and the tilt angle of ****** in the measure point (AF point) of a certain focal location, and the amount of drives <TL1>, <TL2>, and <TL3> of the direction of a focus of the supporting point at each driving points TL1-TL3 of drawing 5 presuppose that it is it 0 (criteria location) in the state of drawing 6 (a), respectively. [ the whole field 26 on exposure side 5a of a wafer ] And as the field 26 shows drawing 6 (b), when the exposing point in the exposure field is reached, the amount of these drives is set as <TL1>=a, <TL2>=b, and <TL3> =c, respectively for exposure. In this case, although only deltaF is changing compared with the case of drawing 6 (a), the focal location of field 26A currently measured in the measure point (AF point) of a focal location Since the effect of the amount of drives in each driving points TL1-TL3 is included in the variation of this deltaF, to next expose field 26A, it is necessary to perform leveling and focusing in the form which amends the amount of drives of each driving points TL1-TL3 in the condition of drawing 6 (b).
[0064] That is, the tilt angle of the focal location measured about field 26A as F1, theta1X, and theta1Y, respectively in the tilt angle of the focal location measured about the field 26 and the direction of X and the tilt angle of the direction of Y and the direction of X and the tilt angle of the direction of Y are made into Fn ', thetanX', and thetanY', respectively. Moreover, when spacing of the direction of X of the measure point (AF point) of a focal location and an exposing point and the direction of Y is set to delta X and delta Y, respectively, the amount deltaF1 of amendments of a focal location is as follows.
deltaF1=-F1-theta1 X-delta X-theta 1 Y-delta Y (13)
[0065] When the amount deltaF1 of amendments is used, the value Fn, thetanX, and thetanY after each amendment of the tilt angle of the focal location measured about field 26A and the direction of X and the tilt angle of the direction of Y are as follows.
Fn =Fn '+deltaF1 (14)
theta nX=theta nX'-theta1X (15)
theta nY=theta nY'-theta1Y (16)
Moreover, it is necessary to manage responsibility to the appearance which is not followed to the uneven side of the RF of the exposure side of a wafer 5. That is, since the response corresponding to a stage location

is required also when the scan speed of a wafer 5 changes, it is made the device which manages the focal location and tilt angle which were measured with the numerical filter for fast Fourier transforms (FFT), or can carry out adjustable [ of the servo gain of the mechanical component of the three supporting points 28A-28C of drawing 5 ] according to a rate. However, the numerical filter for FFT needs a preliminary scan, and since servo gain has phase lag, the device in consideration of these is required.

[0066] (C) a servo gain adjustable method -- here explains per example of the approach of carrying out adjustable [ of the servo gain of the mechanical component of the three supporting points 28A-28C of drawing 5 ] according to a rate. When a response frequency in case the scan speed of a wafer is V/beta is set to nu, transfer function G (s) is expressed as follows.

G(s)=1/(1+Ts) (17)

however, T= 1/(2pinu) and s=2pifi -- it comes out.

[0067] From the analysis result, when scan speed V/beta was 80 mm/s, the response frequency nu of the non-scanning direction had optimal 2Hz, and found that 10Hz was the optimal for the response frequency nu of the scanning direction. However, unevenness of the exposure side of a wafer is expressed with the sine wave of a pitch p, and it is the scan lay length of each shot field on a wafer L0 When it carries out, the frequency f in (17) types is as follows.

f=(V/beta)/L0 and (L0 / p) = (V/beta) / p (18)

Therefore, since a frequency f will change if scan speed V/beta changes, it is necessary to newly ask for the optimal response frequency nu. Thus, servo gain is determined from the response frequency nu for which it asked.

[0068] (D) the numerical filtering method -- since the pitch p of the irregularity on the exposure side of a wafer is a function depending on a stage location here, if the sampling of a focal location is performed by the datum reference synchronizing with a stage location, control independent of scan speed V/beta will be attained. That is, in order to give the filtering effectiveness equivalent to transfer function G (s) with a location function, the inverse Fourier transform of the transfer function G (s) is carried out, it asks for location function F (x), and numerical filtering is performed using this location function F (x). An example of transfer function [ of the response frequency nu ] G (s) is concretely shown in drawing 7 (a), and location function F (x) corresponding to it is shown in drawing 7 (b). However, it is necessary to take run-up scan distance, and at the time of numerical filtering, when not performing this, phase lag arises.

[0069] In addition, also in which approach of an above-mentioned servo gain adjustable method and the numerical filtering methods, responsibility is managed by phase lag and the filtering effectiveness. Phase lag (time lag) is a time lag which exists between the signal corresponding to the focal location made into the target shown by curvilinear 37A of drawing 15 (c), and the signal corresponding to the focal location which is shown by curvilinear 38A, and which was measured in fact. The filtering effectiveness is that only the specified quantity makes the amplitude of an actual focal location small to a focal target location, as the curves 37B and 38B of drawing 15 (d) show.

[0070] As mentioned above, in this example, in case exposure to each shot field of a wafer is performed, the run-up scan which is a preliminary scan may be performed. Then, the setting approach of the run-up scan distance is explained. Drawing 8 (a) shows the scan method in the case of exposing the pattern of a reticle to the next shot fields SA12 and SA13 one by one, after finishing exposure of the shot field SA 11 on a wafer. In this drawing 8 (a), after it scans a wafer in the direction of -Y and the exposure to the shot field SA 11 on a wafer finishes, a wafer is aslant moved to the X-axis and a Y-axis between the acceleration-and-deceleration periods TW1, and it arranges near the lower limit of the next shot field SA 12 in the exposure field of projection optics. After the exposure to the first shot field SA 11 finishes, while moving near the lower limit of the next shot field SA 12, migration of spacing deltaL is performed in the direction of Y. Moreover, in the telophase of the acceleration-and-deceleration period TW1, migration in the direction of Y of a wafer is started.

[0071] Between the subsequent establishment (setting) periods TW2, the scan speed of a wafer reaches about V/beta, and exposure of the pattern of the reticle to the shot field SA 12 is performed between the exposure periods TW3 following it. The acceleration-and-deceleration period TW1, the establishment period TW2, and the exposure period TW3 by the side of a wafer in this case are shown in drawing 8 (c), and the acceleration-and-deceleration period TR1, the establishment period TR2, and the exposure period TR3 by the side of a reticle are shown in drawing 8 (b). In addition, in a reticle side, since it is not necessary to move to the next shot field like drawing 8 (a), migration of the stage by the side of a reticle is a reciprocating motion in alignment with a Y-axis. moreover, the time of extent which shifts to the establishment period TW2 from the acceleration-and-deceleration period TW1 in a wafer side as shown in

drawing 8 (c) -- ts from -- the sampling of the focal location by the multipoint focus location detection system is started.
[0072] In this example, since the responsibility at the time of leveling and focusing is managed by phase lag and the filtering effectiveness, the start point when starting the sampling of a focal location on a wafer changes with situations. For example, as what synchronizes a sampling with a stage location, supposing it performs numerical filtering, a sampling starting position will be determined by the following procedure.
[0073] First, transfer function G (s) is given like drawing 7 (a), and from this transfer function G (s), it asks for location function [ of drawing 7 (b) ] F (x) by the inverse Fourier transform, and asks for die-length deltaL from the zero of this location function F (x) to a zero crossing point. This die-length deltaL is equal to movement magnitude deltaL to the direction of Y at the time of moving aslant because of exposure of the next shot field SA 12, as shown in drawing 8 (a).
[0074] Moreover, to the acceleration-and-deceleration period TR1 of a reticle, since the acceleration-and-deceleration period TW1 of a wafer is small, time amount (TR1-TW1) turns into the latency time by the side of a wafer. in this case, deltaL -- < (V/beta) (TR1-TW1) -- although it does not become the fall of a throughput at the time of **, it becomes the fall of a throughput at the time of deltaL> (V/beta) (TR1-TW1) and **. in addition, delta Y=delta L- (V/beta) (TR1-TW1) and die-length [ which is come out of and expressed ] deltaY is good as a fixed function, if the same filtering effectiveness as transfer function G (s) is acquired even if it processes as phase lag. By performing these filtering, the effectiveness of reducing the effect of the air fluctuation to a multipoint focus location detection system and the control error of a multipoint focus location detection system is also expectable.
[0075] Next, arrangement of the sample point in the measure point of the multipoint focus location detection system in the projection aligner of the slit scan exposure method of this example is considered. First, in drawing 2 (a), among the measure points AF11-AF59 by the multipoint focus location detection system, when using the measurement result of the focal location of the measure points AF31-AF39 in the slit-like exposure field 24 (i.e., when making measure points AF31-AF39 into a sample point), control by same "the exposure position control method" as the conventional stepper's case is performed. Furthermore, since the scan of the wafer of this example is performed in the direction of Y, or the direction of -Y, it is arranging the sample in a measure point before a scanning direction to the exposure field 24, and read-ahead control, time-sharing leveling measurement, measurement value equalization, etc. are attained.
[0076] Read-ahead control means choosing a sample point from the measure point AF 41 before a scan -AF49, AF51-AF59, when scanning a wafer [ like ] in the direction of -Y to the exposure field 24 to drawing 2 (a). By performing read-ahead control, the following error to an actual response frequency becomes |1-G (s) | to transfer function [ of an automatic focus device and an auto leveling device ] G (s). However, since phase lag and a filtering error factor are contained in this following error, phase lag can be removed if read-ahead control is performed. Since this error is 1-G[ |] (s) |, the transfer capacity to be about 4 times many as this can be given.
[0077] Drawing 9 (a) showed the curvilinear 39A corresponding to the focal location which makes into the target at the time of performing the same exposure position control as usual, and the curvilinear 38 B corresponding to the actually set-up focal location, drawing 9 (b) showed the curvilinear 40A corresponding to the focal location made into the target at the time of performing read-ahead control, and the curvilinear 40 B corresponding to the actually set-up focal location, and a phase has shifted in exposure position control. Therefore, the difference Fa of the target position in the case of exposure position control and a flattery location will be about 4 times the difference Fb of the target position in read-ahead control, and a flattery location. Therefore, in read-ahead control, the transfer capacity to be about 4 times many as this can be given.
[0078] However, the response frequency of auto leveling will be good for the already described appearance in the scanning direction at the filtering response of about 2.5Hz, when it performs read-ahead control in the scanning direction, since about 10Hz is suitable (position control method). When a numerical filter or control gain performs this filtering, the run-up scan length of 5(**80/(2pi*2.5)) mm extent is needed before exposure, using the scan speed of a wafer as 80mm. The focal error by both the controlling method is shown below.
[0079] Therefore, like the case of drawing 17 , it turns at the period of the periodic deflection of the scanning direction of the shot field SAij on a wafer as a value of a ratio with the width of face of the scanning direction, and expresses with Parameter F, and the focal error in each measure point in case there is the periodic deflection is expressed with the absolute value of the average of the error of the focal location in each measure point, and one third of the sums of the amplitude of the error of a focal location. Moreover,

the amplitude of the periodic deflection of the deflection parameter F is standardized to 1, and the error parameter S which shows the maximum of the focal errors in each [ these ] measure point in case a deflection parameter is F is expressed as a ratio to the deflection parameter F.
[0080] When drawing 10 (a) performs exposure position control, the response frequency fm of leveling of the scanning direction expresses the error parameter S to the deflection parameter F in case the response frequency fn of leveling of 10Hz and the non-scanning direction is 2Hz, curvilinear A9 and B9 show the error parameter S in the non-scanning direction, and both the curves A10 and B10 of both show the error parameter S in the scanning direction. On the other hand, when drawing 17 (b) performs read-ahead control, the response frequency fm of leveling of the scanning direction expresses the error parameter S to the deflection parameter F in case the response frequency fn of leveling of 2.5Hz and the non-scanning direction is 0.5Hz, curves A11 and B11 show the error parameter S in the non-scanning direction, and both the curves A12 and B12 of both show the error parameter S in the scanning direction.
[0081] In order to improve a response, it is good, but it is not suitable to remove phase lag by read-ahead control as mentioned above, when reducing a response. However, read-ahead control has many degrees of freedom by software, and can also perform a prediction setup of the measure point of the focal location in the time of time equalization and exposure initiation as shown by drawing 11 . That is, in drawing 11 (a), a focal location is detected only for the die length of width-of-face deltaL in a front sample point (AF point) to the scanning direction of a multipoint focus location detection system to certain field 26B on exposure side 5a of a wafer. And as shown in drawing 11 (b), when field 26B reaches an exposing point, the information on the focal location detected in the range of width-of-face deltaL is equalized, and leveling and focusing are performed with high precision.
[0082] Moreover, as shown in drawing 11 (c), even if level difference section 26C is in exposure side 5a of a wafer by the case where a measure point and an exposing point are equal, by the exposure position control method, as shown in drawing 11 (d), the field (focal field) AFP made into a focal object only goes up gradually, and exposure is performed in the condition of having been defocused in the level difference section 26C. On the other hand, when level difference section 26D is in exposure side 5a of a wafer, as are shown in drawing 11 (e), and it is beforehand shown in drawing 11 (f) according to the level difference by the case where the measure point and the exposing point are separated by the read-ahead controlling method, exposure is performed in the condition of having focused, by going up the focal side AFP gradually at the level difference section 26D.
[0083] In addition, it has not only the read-ahead controlling method but the usual exposure position control method, and it is desirable to use the two controlling methods as a selectable system. Since there are the above functions in the automatic focus and auto leveling device of this example, in order to actually control the exposure side of a wafer, the method of controlling three kinds which consists of ** exposure position control, ** full read-ahead control, and ** division read-ahead control can be considered. Below, it explains to these three kinds of controlling method per details.
(F) Perform the focal location of the exposure side of a wafer, and control of a leveling angle using the value of the focal location measured and obtained regardless of the response engine performance of an automatic focus and an auto leveling device at all at the time of exposure by the exposure position control method this gentleman formula. Namely, as shown in drawing 12 (a), the odd-numbered measure point of 3rd train 25C in the exposure field 24 is also made into a sample point to the exposure field 24 in a scanning direction (the direction of Y) by making the even-numbered measure point of 2nd train 25B of a near side into the sample point 41. And leveling control of the scanning direction of the exposure side of a wafer is performed from the measurement value of the focal location in the sample point of 2nd train 25B, and the measurement value of the focal location in the sample point of 3rd train 25C.
[0084] Moreover, the inclination of the non-scanning direction is calculated by the least-squares-approximation method from the measurement value of the focal location in the sample point of 2nd train 25B and 3rd train 25C, and leveling control of the non-scanning direction is performed. Moreover, focal control also uses the measurement value of the focal location in the measure point of the 3rd train in the exposure field 24, and performs focal control. In addition, a sample point is chosen from the measure point of 3rd train 25C and 4th train 25D when the scanning direction of a wafer is the direction of -Y, as shown in drawing 12 (b). By this method, although control is the easiest, there is un-arranging [ that flattery precision will change with the scan speed of a wafer etc. ]. Moreover, the calibration of the focal location in each measure point of 2nd train 25B and 3rd train 25C is required.
[0085] (G) As shown in drawing 12 (c), measure all the values of the focal location in the sample point of 1st train 25A before exposure beforehand to the exposure field 24 by the full read-ahead controlling method

this gentleman formula in the scanning direction by making all the measure points of 1st train 25A of a near side into a sample point. And equalization processing and filtering processing are performed, phase lag is expected, it is open at the time of exposure, and an automatic focus and an auto leveling device are controlled at it. Namely, the measurement value of the focal location in each sample point of 1st train 25A is memorized, the inclination of the scanning direction is computed from the value of the focal location measured on the time-axis, and leveling control of the scanning direction is performed by opening control at the time of exposure.

[0086] In parallel to it, the inclination of the non-scanning direction is calculated by the least-squares-approximation method from the measurement value of the focal location in each sample point of 1st train 25A, and leveling control of the non-scanning direction is performed by opening control. Since it is a read ahead, equalization on a time-axis is also possible. Moreover, the measurement value of the focal location in each sample point of 1st train 25A is memorized, and focal doubling is performed by opening control at the time of exposure. In addition, as shown in drawing 12 (d), when the scanning direction of a wafer is the direction of -Y, all the measure points of 5th train 25E are chosen as a sample point.

[0087] By this method, since a sample point can secure nine points in 1st train 25A, there is much amount of information and the improvement in precision is expectable. Moreover, since a sample point is one line, it both has the advantage with an unnecessary calibration that management of responsibility can be performed. On the other hand, when it measures directly about the sample point of 1st train 25A, in order to expose the edge of each shot field, the distance (run-up scan length) which should be scanned becomes long, and there is un-arranging [ to which a throughput falls ]. Moreover, since it is opening control, there is also un-arranging [ that the check by the multipoint focus location detection system cannot be performed ].

[0088] (H) By the division read-ahead controlling method this gentleman formula, as shown in drawing 12 (e), also make the even-numbered measure point of 3rd train 25C in the exposure field 24 into a sample point to the exposure field 24 in a scanning direction (the direction of Y) by making the odd-numbered measure point of 2nd train 25B of a near side into a sample point. And in the sample point of 2nd train 25B and 3rd train 25C, all the values of a focal location are beforehand measured before exposure. Then, equalization processing and filtering processing are performed, phase lag is expected, and it controls by opening control at the time of exposure. Namely, the measurement value of the focal location in the sample point of 2nd train 25B and 3rd train 25C is memorized, the inclination of the scanning direction is computed from the value of the focal location measured on the time-axis, and leveling of the scanning direction is performed by opening control at the time of exposure.

[0089] Moreover, the inclination of the non-scanning direction is calculated by the least-squares-approximation method from the measurement value of the focal location in the sample point of 2nd train 25B and 3rd train 25C, and leveling of the non-scanning direction is performed by opening control. Since it is a read ahead, equalization on a time-axis is also possible. Moreover, the measurement value of the focal location in the sample point of 2nd train 25B and 3rd train 25C is memorized, and focal doubling is performed by opening control at the time of exposure. In addition, a sample point is chosen from the measure point of 3rd train 25C and 4th train 25D when the scanning direction of a wafer is the direction of -Y, as shown in drawing 12 (f).

[0090] By this method, since 2nd train 25B (or 4th train 25D) is close to the exposure field 24, while being able to lessen run-up scan distance for exposing the edge of each shot field of a wafer, there is an advantage that management of responsibility can be performed. Moreover, the check of the result of having controlled the exposure side by opening control from the measurement value of the focal location in the sample point of 3rd train 25C at the time of exposure is possible. On the other hand, there is un-arranging [ that the calibration of the focal location in the sample point of 2nd train 25B and the focal location in the sample point of the 3rd train is required ].

[0091] Moreover, by the full read-ahead controlling method, as shown in drawing 13 (a) - (d), a more exact automatic focus and auto leveling control are performed by changing the sample point of under exposure initiation and exposure and the focal location just before exposure termination. That is, as shown in drawing 13 (a), when the shot field SA which should be exposed arrives at the location of spacing D (it is the same as the width of face of the scanning direction of the exposure field 24) to the exposure field 24, measurement of the focal location by the multipoint focus location detection system is started in the sample field 42 of spacing D from the exposure field 24. An example of width of face D, i.e., the width of face of the scanning direction of the exposure field 24, is 8mm. Then, as shown in drawing 13 (b), when the point of the shot field SA contacts the exposure field 24, leveling control of the scanning direction is performed based on the measurement value of the focal location in the detection region 44 between two sample points on a wafer,

and automatic focus control is performed based on the measurement value of the focal location in the detection region 45 which consists of one sample point.
[0092] Next, as shown in drawing 13 (c), when the point of the shot field SA goes into the exposure field 24, leveling control of the scanning direction is performed based on the measurement value of the focal location in the detection region 44 between two sample points on a wafer, and automatic focus control is performed based on the measurement value of the focal location in the detection region 45 between two sample points. Moreover, as shown in drawing 13 (d), when the shot field SA comes to cover the exposure field 24, based on the measurement value of the focal location in the wrap detection region 44, leveling control of the scanning direction is performed in the exposure field 24, and automatic focus control is performed based on the measurement value of the focal location in the wrap detection region 45 in the exposure field 24.
[0093] On the other hand, also by the division read-ahead controlling method, as shown in drawing 13 (e) - (h), a more exact automatic focus and auto leveling control are performed by changing the sample point of under exposure initiation and exposure and the focal location just before exposure termination. Namely, as shown in drawing 13 (e), when the shot field SA which should be exposed arrives at the location of spacing D / 2 (1/2 of the width of face of the scanning direction of the exposure field 24) to the exposure field 24, measurement of the focal location by the multipoint focus location detection system is started from the exposure field 24 by sample field 43B of spacing D / 2 outside from sample field 43A of spacing D / 2, and the exposure field 24 to the inside. Then, as shown in drawing 13 (f), when the point of the shot field SA contacts the exposure field 24, based on the measurement value of the focal location in the wrap detection region 46, leveling control of the scanning direction is performed in the exposure field 24, and automatic focus control is performed based on the measurement value of the focal location in the detection region 47 which consists of one sample point.
[0094] Next, as shown in drawing 13 (g), when the point of the shot field SA enters in the exposure field 24 only in width-of-face D / 2, based on the measurement value of the focal location in the wrap detection region 46, leveling control of the scanning direction is performed in the exposure field 24, and automatic focus control is performed based on the measurement value of the focal location in the detection region 47 of width-of-face D / 2. Moreover, as shown in drawing 13 (h), when the shot field SA comes to cover the exposure field 24, based on the measurement value of the focal location in the wrap detection region 46, leveling control of the scanning direction is performed in the exposure field 24, and automatic focus control is performed based on the measurement value of the focal location in the wrap detection region 47 in the exposure field 24. Drawing 13 shows that run-up scan length (= D/2) is made to one half compared with the perfect predicting method by the division predicting method.
[0095] In addition, in the above-mentioned example, in order to measure the focal location of the multipoint of the exposure side of a wafer, the multipoint focus location detection system which projects on a wafer the opening pattern image of the shape of a slit arranged two-dimensional is used. Carrying out a deer, the image of the pattern which is the shape of a slit long and slender in the non-scanning direction may be projected on a wafer, and the 1-dimensional focal location detection system which measures the focal location of the whole non-scanning direction may be used [ instead ]. Moreover, even when measuring distribution of the two-dimensional focal location on the exposure side of a wafer using the focal location detection system of an image-processing method, highly precise focusing and highly precise leveling can be performed by applying the same division read ahead as the above-mentioned example etc. Furthermore, leveling actuation of only the non-scanning direction may be performed in this example, without performing leveling actuation of the scanning direction to the leveling error of the non-scanning direction, since the leveling error of the scanning direction is small so that drawing 17 may show.
[0096] In addition, of course, configurations various in the range which this invention is not limited to the above-mentioned example, and does not deviate from the summary of this invention can be taken.
[0097]
[Effect of the Invention] According to the 1st field location equipment of this invention, in the projection aligner of a slit scan exposure method, the error by the irregularity of the front face of a sensitization substrate, the measurement precision of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the exposure side of a sensitization substrate can be doubled in parallel with high precision to the image surface of projection optics.
[0098] Moreover, when the sensitization substrate is scanned through the substrate side stage and a multipoint measurement means samples the height of the sensitization substrate in two or more measure points by the datum reference of a substrate side stage, the tilt angle of a scanning direction can be measured more to high degree of accuracy. Moreover, in measuring the height of the sensitization substrate,

respectively in two or more measure points when a multipoint measurement means becomes from two or more points in the field of this side at the time of a sensitization substrate being scanned to the inside of two or more points in an exposure field [ **** ], and the exposure field [ **** ] of those about the lighting field and the projection optics of a predetermined configuration, there is an advantage which can shorten the run-up scan distance at the time of initiation of exposure by division read-ahead control.

[0099] Moreover, when a multipoint measurement means changes the location of two or more measure points to one shot field of a sensitization substrate one by one in the process which exposes the pattern of a mask one by one, both leveling precision and a throughput can be improved by using together for example, a division read ahead and a full read ahead. Moreover, according to the 2nd field location equipment of this invention, in the projection aligner of a slit scan exposure method, the error by the irregularity of the front face of a sensitization substrate, the measurement precision of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the focal location of the exposure side of a sensitization substrate can be correctly doubled to the image surface of projection optics.

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[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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DRAWINGS

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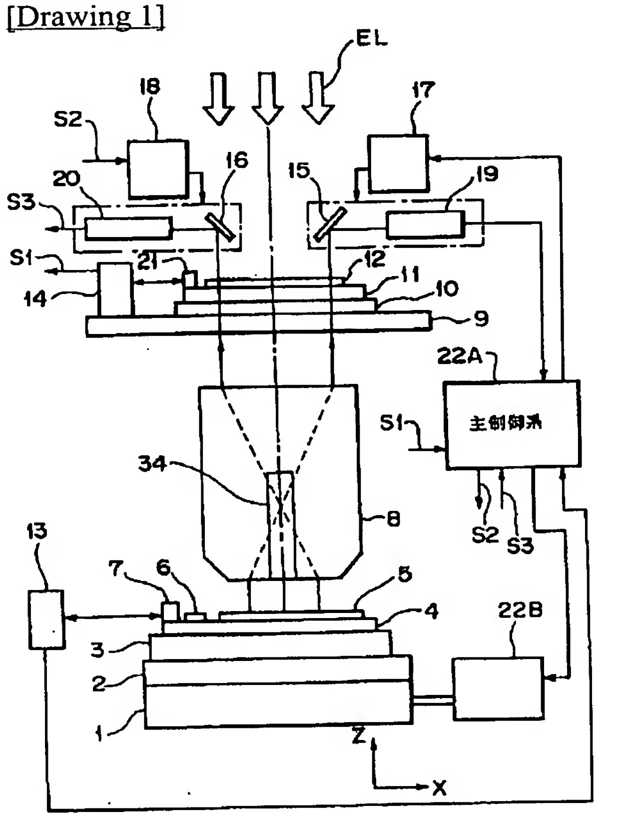
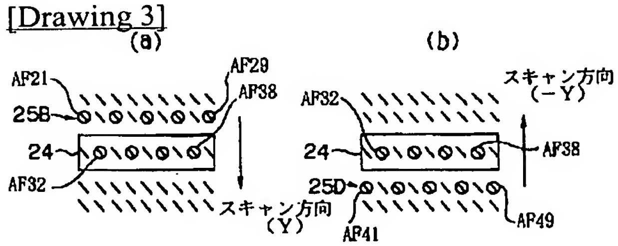
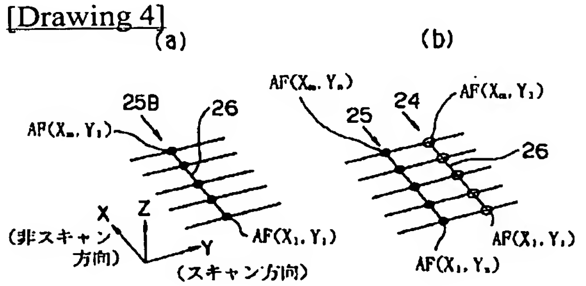
[Drawing 1]



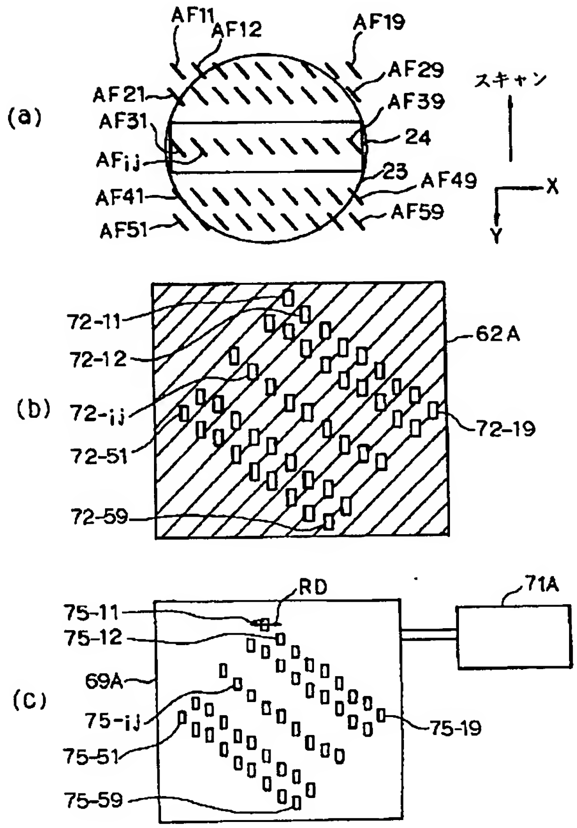

[Drawing 3]



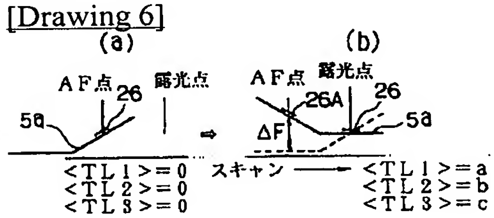

[Drawing 4]



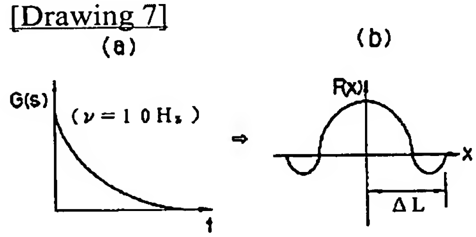

[Drawing 2]



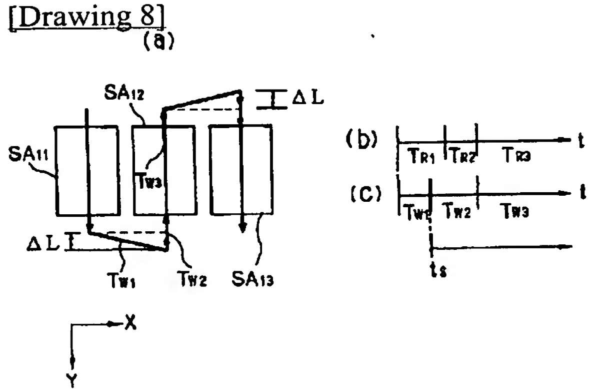

[Drawing 6]



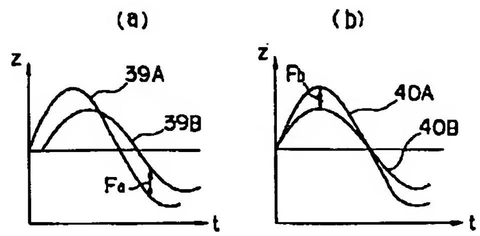

[Drawing 7]



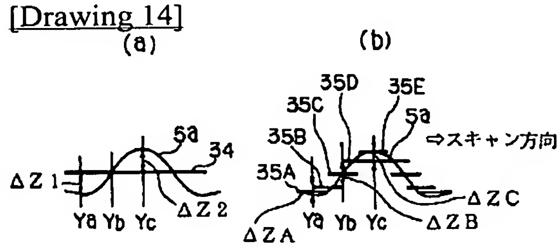

[Drawing 8]



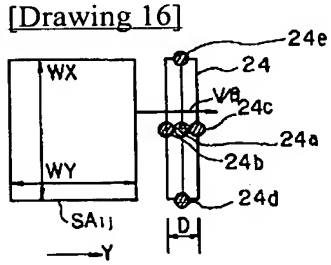

[Drawing 9]



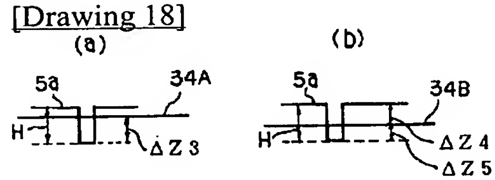

[Drawing 14]



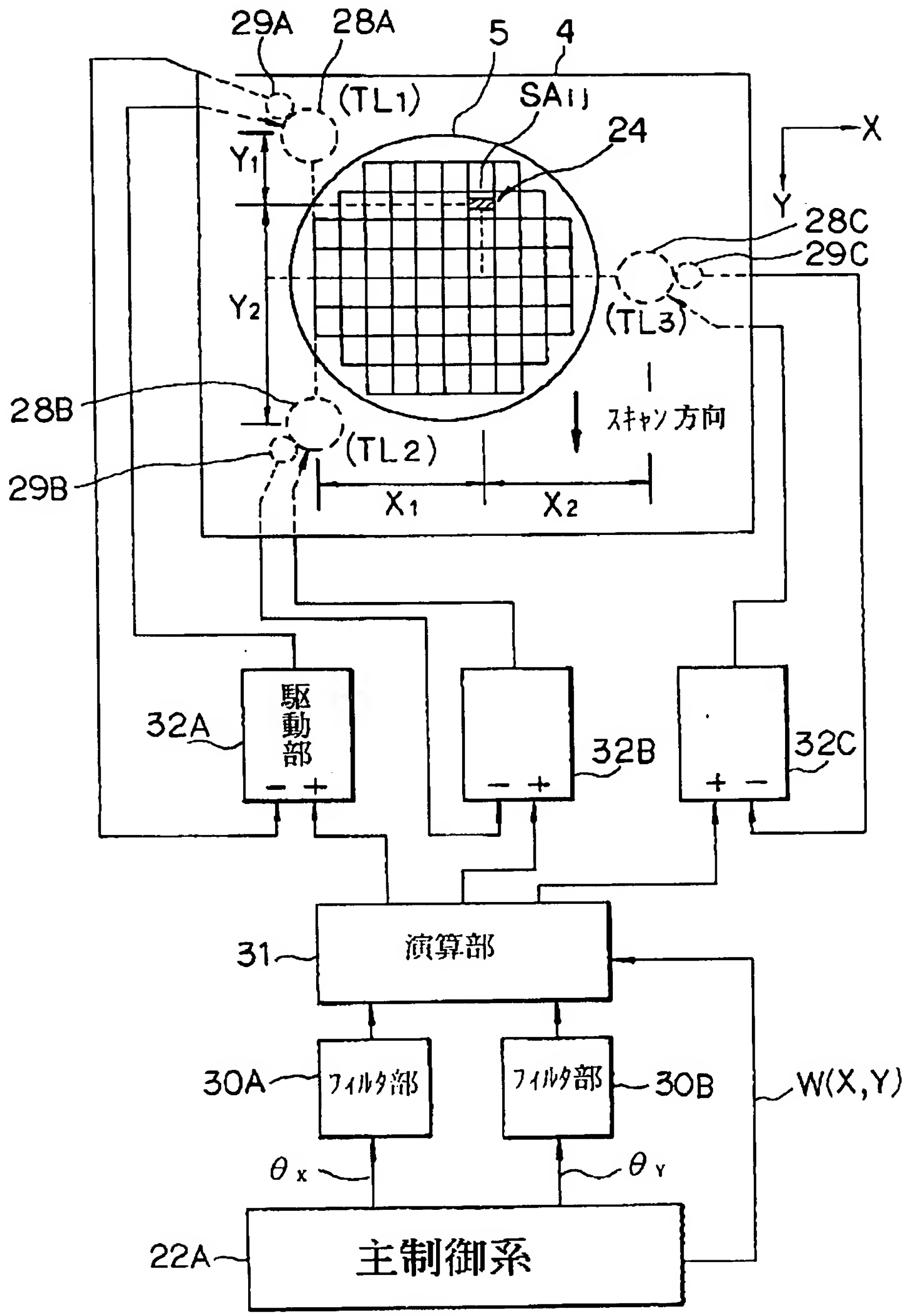

[Drawing 16]



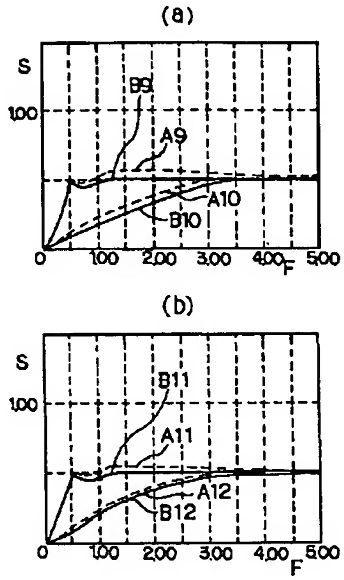

[Drawing 18]



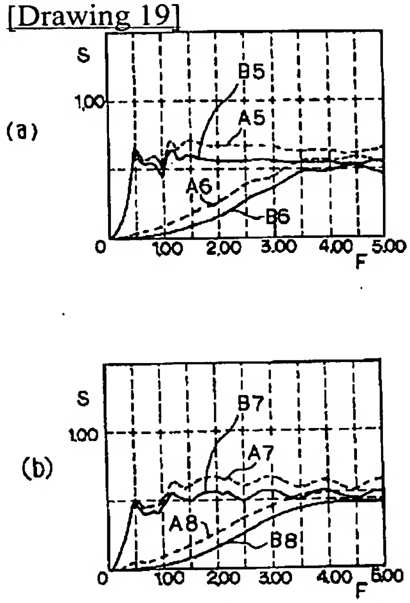

[Drawing 5]


29A
28A
5
4
(TL1)
SAij
24
X
Y
Y1
Y2
28C
29C
(TL3)
28B
29B
(TL2)
スキャン方向
X1
X2
駆動部
32A
32B
32C
31
演算部
30A
フィルタ部
フィルタ部
30B
W(X,Y)
θx
θY
22A
主制御系

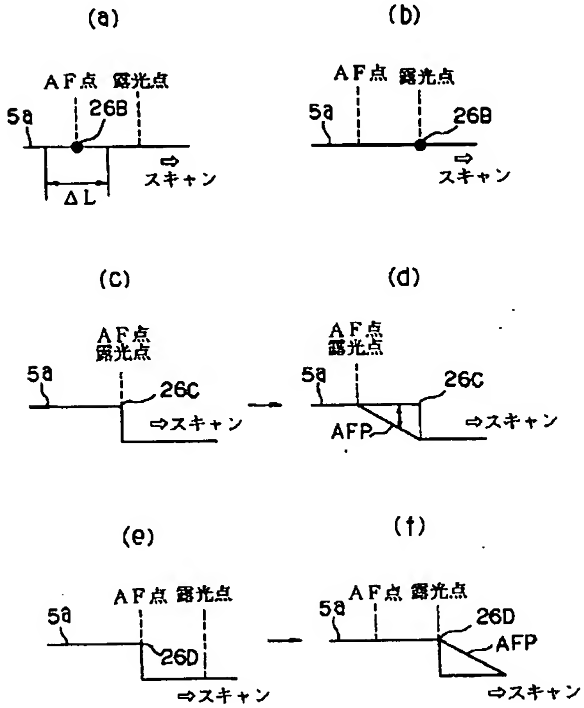
[Drawing 10]



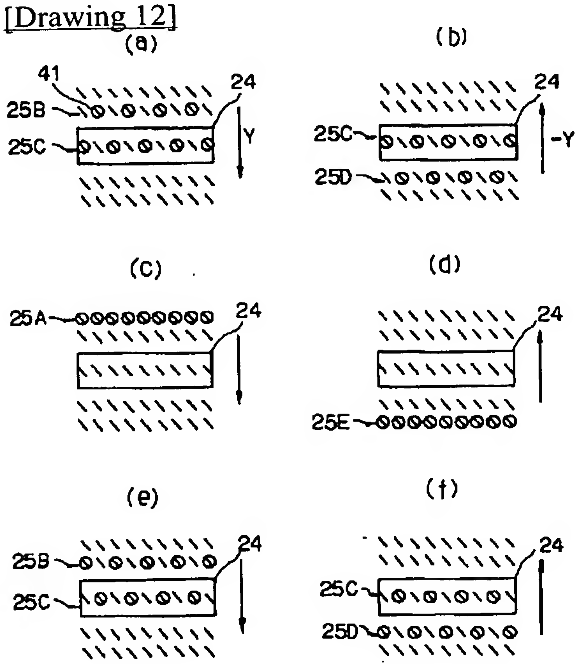

[Drawing 19]



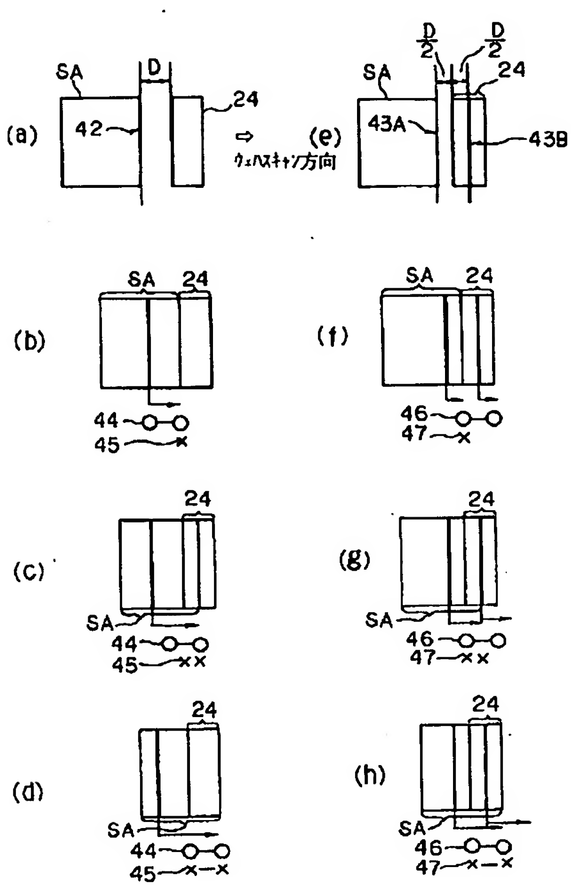

[Drawing 11]



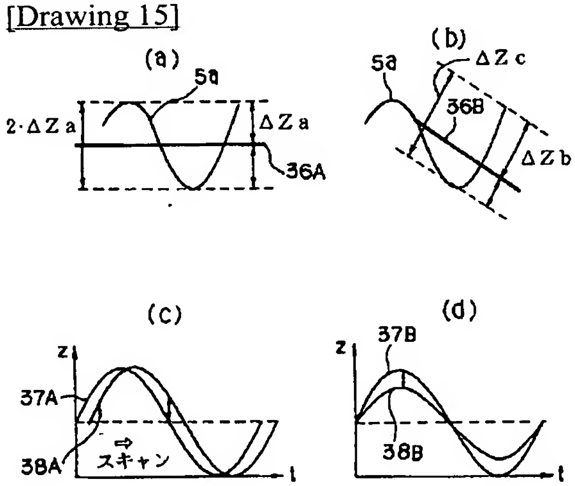

[Drawing 12]



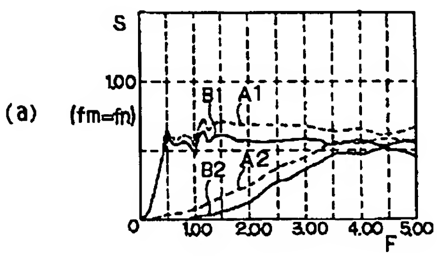

[Drawing 13]

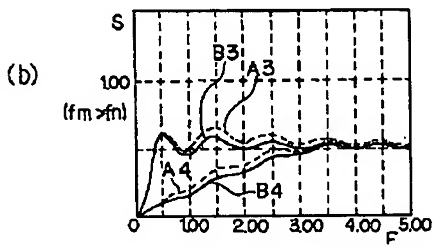



[Drawing 15]

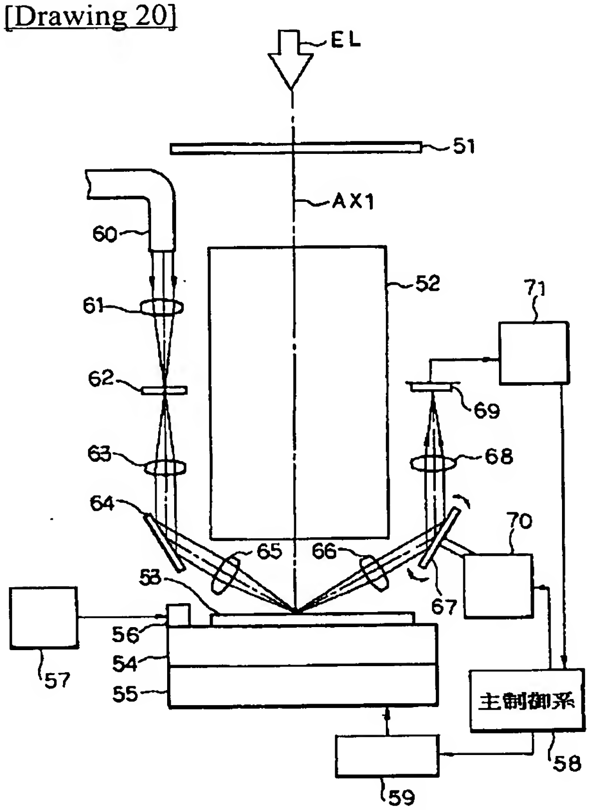



[Drawing 17]



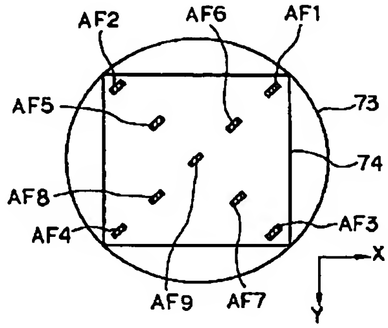




[Drawing 20]

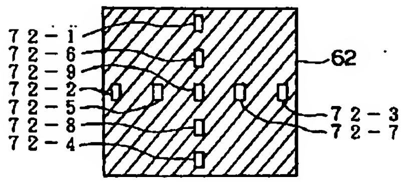



[Drawing 21]

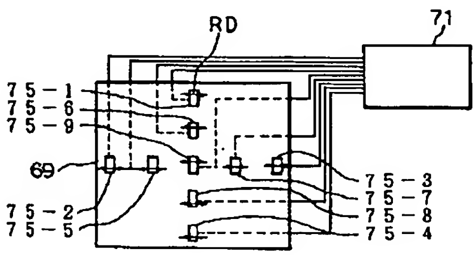
(a)




(b)




(c)

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[Translation done.]

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CORRECTION OR AMENDMENT

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[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 2nd partition of the 7th section
[Publication date] March 23, Heisei 13 (2001. 3.23)

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H01L  21/027
G03B  27/32
G03F   9/00
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[FI]

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H01L  21/30    311 N
G03B  27/32        F
G03F   9/00        H
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[Procedure revision]
[Filing Date] June 14, Heisei 11 (1999. 6.14)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] The name of invention
[Method of Amendment] Modification
[Proposed Amendment]
[Title of the Invention] The scan exposure approach, field location equipment, a scanning aligner, and the device manufacture approach that uses said approach
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] The illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light, and the mask side stage which scans the mask in which the pattern for exposure was formed to said lighting field, The projection optics which projects the pattern of said mask in said lighting field on a sensitization substrate, It is field location equipment for being prepared in the aligner which has the substrate side stage which scans said sensitization substrate synchronizing with said mask, and doubling the exposure side of said sensitization substrate in parallel with the image surface of said projection optics,
A multipoint measurement means to measure the height of a direction parallel to the optical axis of said projection optics of said sensitization substrate in two or more measure points including two or more points of the direction which crosses in the direction in which said sensitization substrate is scanned, respectively,

An operation means to ask for the difference of the tilt angle between the exposure side of said sensitization substrate, and the image surface of said projection optics from the measurement result of this multipoint measurement means,
It is prepared in said substrate side stage, and has the inclination setting stage which sets up the tilt angle of the direction which intersects perpendicularly in the tilt angle of the direction of said scan of said sensitization substrate, and the direction of said scan based on the difference of said tilt angle called for by said operation means,
Field location equipment characterized by making a speed of response in case this inclination setting stage sets up the tilt angle of the direction of said scan of said sensitization substrate differ from the speed of response when setting up the tilt angle of the direction which intersects perpendicularly towards said scan.
[Claim 2] Said multipoint measurement means is field location equipment according to claim 1 characterized by sampling the height of said sensitization substrate in said two or more measure points by the datum reference of said substrate side stage when said sensitization substrate is scanned through said substrate side stage.
[Claim 3] Said multipoint measurement means is field location equipment according to claim 1 or 2 characterized by measuring the height of said sensitization substrate, respectively in two or more measure points which consist of two or more points in the field of this side at the time of said sensitization substrate being scanned to the inside of two or more points in an exposure field [ **** ], and said exposure field [ **** ] about the lighting field and said projection optics of said predetermined configuration.
[Claim 4] Said multipoint measurement means is field location equipment according to claim 1 characterized by changing the location of the measure point of the sequential aforementioned plurality to one shot field of said sensitization substrate in the process which exposes the pattern of the sequential aforementioned mask.
[Claim 5] The illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light, and the mask side stage which scans the mask in which the pattern for exposure was formed to said lighting field, The projection optics which projects the pattern of said mask in said lighting field on a sensitization substrate, It is field location equipment for being prepared in the aligner which has the substrate side stage which scans said sensitization substrate synchronizing with said mask, and doubling the height of the exposure side of said sensitization substrate with the image surface of said projection optics,
A height measurement means to measure the height of a direction parallel to the optical axis of said projection optics of said sensitization substrate in the predetermined measure point in the measurement field which consists of a field of this side at the time of said sensitization substrate being scanned to an exposure field [ **** ] and this exposure field about the lighting field and said projection optics of said predetermined configuration,
An operation means to ask for the difference of the average height of the exposure side of said sensitization substrate, and the height of the image surface of said projection optics based on the maximum and the minimum value of two or more height measurement results obtained by said height measurement means when said sensitization substrate is scanned,
Field location equipment characterized by having the height setting stage which sets up the height of said sensitization substrate based on the difference of said height which was prepared in said substrate side stage and found by said operation means.
[Claim 6] In the scanning aligner which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
A detection means to detect the positional information of said 2nd body about the direction of an optical axis of said projection system in two or more measure points during migration of said 2nd body,
It has a setting means to set up the inclination of said 2nd body during migration of said 2nd body based on the detection result of said detection means,
This setting means is a scanning aligner characterized by changing the speed of response when setting up the inclination of the speed of response when setting up the inclination of the migration direction of said 2nd body, the migration direction of said 2nd body, and the crossing direction.
[Claim 7] In the scanning aligner which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
A detection means to detect the positional information of said 2nd body about the direction of an optical axis

of said projection system in two or more measure points during migration of said 2nd body,
The adjustment device which adjusts the physical relationship of the image surface of said projection system, and said 2nd body during migration of said 2nd body based on the maximum of the positional information detected at two or more detecting points of said detection means, and the minimum value,
The scanning aligner characterized by preparation ******.
[Claim 8] Said adjustment device is a scanning aligner according to claim 7 characterized by performing weighting to said maximum and said minimum value, and making the field of the request on said 2nd body substantially in agreement with the image surface of said projection system.
[Claim 9] Said adjustment device is a scanning aligner according to claim 7 or 8 characterized by adjusting the inclination relation between the image surface of said projection system, and said 2nd body about the migration direction of said 2nd body, and the crossing direction.
[Claim 10] In the scanning aligner which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
A detection means to detect the positional information of said 2nd body about the direction of an optical axis of said projection system in two or more detecting points during migration of said 2nd body,
An alignment means to carry out weighting to the positional information detected at two or more detecting points of said detection means, and to perform alignment of the field of the request on said 2nd body, and the image surface of said projection system during migration of said 2nd body,
The scanning aligner characterized by preparation ******.
[Claim 11] Said alignment means is a scanning aligner according to claim 10 characterized by adjusting the inclination relation between the request side on said 2nd body, and the image surface of said projection system about the migration direction of said 2nd body, and the crossing direction.
[Claim 12] Said alignment means is a scanning aligner according to claim 10 or 11 characterized by having an independently movable respectively supporting point, adjusting the movement magnitude of this supporting point, respectively, and performing alignment of the image surface of said projection system, and the field of the request on said 2nd body while supporting said 2nd body.
[Claim 13] In the scanning aligner which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
A detection means to detect the positional information of said 2nd body about the direction of an optical axis of said projection system at two or more detecting points during migration of said 2nd body,
It has a setting means to perform a field setup of said 2nd body to the image surface of said projection system during migration of said 2nd body based on the detection result of said detection means,
The scanning aligner characterized by changing the speed of response when performing a field setup of said 2nd body according to the passing speed of said 2nd body.
[Claim 14] Said speed of response is a scanning aligner according to claim 13 characterized by being managed with a filter.
[Claim 15] Modification of said speed of response is a scanning aligner according to claim 13 characterized by including modification of the servo gain of the mechanical component of said setting means.
[Claim 16] Said detection means is a scanning aligner given in any 1 term of claims 6-15 characterized by having a detecting point in the exposure field of the exposure beam which passed said projection system.
[Claim 17] Said detection means is a scanning aligner given in any 1 term of claims 6-15 characterized by having the detecting point which is distant from the exposure field of the exposure beam which passed said projection system.
[Claim 18] Said two or more detecting points are scanning aligners given in any 1 term of claims 6-17 characterized by being separated and set up in the migration direction of said 2nd body, and the crossing direction.
[Claim 19] Said two or more detecting points are scanning aligners according to claim 18 characterized by being arranged two-dimensional.
[Claim 20] In the scanning aligner which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
A detection means to detect the concavo-convex information on the exposure side of said 2nd body,
In order to perform alignment of the exposure side of said 2nd body, and the image surface of said projection system during scan exposure of the exposure side of said 2nd body, it has a setting means to

perform a field setup of said exposure side based on the concavo-convex information detected with said detection means,
This setting means is a scanning aligner characterized by controlling a field setup which worsens the alignment precision of said image surface and said exposure side.
[Claim 21] The scanning aligner according to claim 20 characterized by detecting the concavo-convex information on the exposure side of said 2nd body with said detection means in advance of scan exposure of said 2nd body, moving said 2nd body in order to control said field setup.
[Claim 22] Said detection means is a scanning aligner according to claim 20 or 21 characterized by detecting said concavo-convex information, when the positional information of the exposure side of said 2nd body about the direction of an optical axis of said projection system measures in two or more measure points during migration of said 2nd body.
[Claim 23] Said setting means is a scanning aligner given in any 1 term of claims 20-22 characterized by having a control means for controlling said field setup.
[Claim 24] Said control means is a scanning aligner according to claim 23 characterized by controlling said field setup by carrying out filtering processing of the information detected with said detection means.
[Claim 25] Said setting means is a scanning aligner given in any 1 term of claims 20-23 characterized by controlling said field setup by having a mechanical component for moving the supporting point of said 2nd body in the direction of an optical axis of said projection system, and adjusting the servo gain of this mechanical component.
[Claim 26] Said servo gain is a scanning aligner according to claim 25 characterized by being adjustable according to the passing speed of said 2nd body.
[Claim 27] Said setting means is a scanning aligner given in any 1 term of claims 20-26 characterized by controlling a setup of the inclination of the exposure side of said 2nd body.
[Claim 28] The device manufacture approach using a scanning aligner given in any 1 term of claims 6-27.
[Claim 29] In the scan exposure approach which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
The scan exposure approach characterized by changing the speed of response when setting up the inclination of the speed of response when setting up the inclination of the migration direction of said 2nd body, the migration direction of said 2nd body, and the crossing direction in case the inclination of said 2nd body is set up during migration of said 2nd body.
[Claim 30] In the scan exposure approach which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
The scan exposure approach characterized by changing the speed of response when setting up the inclination of the migration direction of said 2nd body according to the passing speed of said 2nd body in case the inclination of said 2nd body is set up during migration of said 2nd body.
[Claim 31] In the scan exposure approach which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
The scan exposure approach characterized by adjusting the physical relationship of the image surface of said projection system, and said 2nd body based on the maximum of the positional information detected at these two or more detecting points, and the minimum value while detecting the positional information of said 2nd body about the direction of an optical axis of said projection system in two or more measure points during migration of said 2nd body.
[Claim 32] In the scan exposure approach which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
The scan exposure approach which carries out weighting to the positional information which detects the positional information of said 2nd body about the direction of an optical axis of said projection system in two or more detecting points, and is detected at these two or more detecting points during migration of said 2nd body, and is characterized by the thing of the field of the request on said 2nd body, and the image surface of said projection system to do for alignment.
[Claim 33] Said two or more detecting points are the scan exposure approaches according to claim 31 or 32 characterized by including the detecting point in the exposure field of the exposure beam which passed said projection system.

[Claim 34] Said two or more detecting points are the scan exposure approaches given in any 1 term of claims 31-33 characterized by including the detecting point which is distant from the exposure field of the exposure beam which passed said projection system.
[Claim 35] Said two or more detecting points are the scan exposure approaches according to claim 33 or 34 characterized by including two or more detecting points which separated in the migration direction of said 2nd body, and the crossing direction.
[Claim 36] In the scan exposure scan exposure approach which carries out scan exposure of said 2nd body by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam,
The scan exposure approach characterized by controlling a field setup which worsens the alignment precision of said image surface and said exposure side when carrying out scan exposure of said exposure side, performing a field setup of said exposure side based on the concavo-convex information on said exposure side in order to perform alignment of the exposure side of said 2nd body, and the image surface of said projection system.
[Claim 37] The scan exposure approach according to claim 36 characterized by detecting the concavo-convex information on the exposure side of said 2nd body in advance of scan exposure of said 2nd body, moving said 2nd body in order to control said field setup.
[Claim 38] Said concavo-convex information is the scan exposure approach according to claim 37 characterized by asking when the positional information of the exposure side of said 2nd body about the direction of an optical axis of said projection system detects in two or more measure points, moving said 2nd body.
[Claim 39] Control of said field setup is the scan exposure approach given in any 1 term of claims 36-38 characterized by including control of an inclination setup of the exposure side of said 2nd body.
[Claim 40] The device manufacture approach using the scan exposure approach given in any 1 term of claims 29-39.
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] 0001
[Method of Amendment] Modification
[Proposed Amendment]
[0001]
[Industrial Application] This invention is used for the projection aligner of the slit scan exposure method equipped with for example, the automatic focus device or the auto leveling device, and relates to the suitable scan exposure approach. Furthermore, this invention relates to the device manufacture approach which uses the scan exposure approach for the field location equipment which can be used in case such a scan exposure approach is enforced and a scanning aligner, and a list.
[Procedure amendment 4]
[Document to be Amended] Specification
[Item(s) to be Amended] 0014
[Method of Amendment] Modification
[Proposed Amendment]
[0014] This invention aims at offering the scan exposure approach which can be used in the projection aligner of a slit scan exposure method in order to double the exposure side of a sensitization substrate with high precision to the image surface of projection optics in view of this point. Furthermore, this invention aims also at offering the device manufacture approach that a device can be manufactured with high precision using the scan exposure approach in the field location equipment which can be used in case the scan exposure approach is enforced and a scanning aligner, and a list.
[Procedure amendment 5]
[Document to be Amended] Specification
[Item(s) to be Amended] 0018
[Method of Amendment] Modification
[Proposed Amendment]
[0018] Moreover, as for the multipoint measurement means, it is desirable to change the location of the measure point of these plurality to one shot field of a sensitization substrate (5) one by one in the process which exposes the pattern of a mask (12) one by one. Moreover, the 2nd field location equipment by this invention The mask side stage which scans the mask (12) with which the pattern for exposure was formed to

the lighting field with the illumination-light study system which illuminates the lighting field of a predetermined configuration with exposure light (10), The projection optics which projects the pattern of the mask in the lighting field (12) on a sensitization substrate (5) (8), It is prepared in the aligner which has the substrate side stage (2) which scans a sensitization substrate (5) synchronizing with a mask (12). It is field location equipment for doubling the height of the exposure side of a sensitization substrate (5) with the image surface of projection optics (8). In the predetermined measure point in the measurement field which consists of a field of this side at the time of a sensitization substrate (5) being scanned to an exposure field [ **** ] (24) and this exposure field about the lighting field and projection optics (8) of that predetermined configuration A height measurement means to measure the height of a direction parallel to the optical axis of the projection optics (8) of a sensitization substrate (5) (62A, 69A), The inside of two or more height measurement results obtained by the height measurement means when a sensitization substrate (5) is scanned, An operation means to ask for the difference of the average height of the exposure side of a sensitization substrate (5), and the height of the image surface of projection optics (8) based on maximum and the minimum value (71A), It is prepared in a substrate side stage (2), and has the height setting stage (4) which sets up the height of a sensitization substrate (5) based on the difference of the height found by the operation means (71A). Next, the 1st scanning aligner by this invention By moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam A detection means to detect the positional information of the 2nd body about the direction of an optical axis of the projection system in two or more measure points during migration of the 2nd body in the scanning aligner which carries out scan exposure of the 2nd body, It has a setting means to set up the inclination of the 2nd body during migration of the 2nd body based on the detection result of the detection means. This setting means The speed of response when setting up the inclination of the speed of response and the migration direction of the 2nd body of [ when setting up the inclination of the migration direction of the 2nd body ], and the crossing direction is changed. Moreover, the 2nd scanning aligner by this invention By moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam A detection means to detect the positional information of the 2nd body about the direction of an optical axis of the projection system in two or more measure points during migration of the 2nd body in the scanning aligner which carries out scan exposure of the 2nd body, It has the adjustment device which adjusts the physical relationship of the image surface and the 2nd body of the projection system during migration of the 2nd body based on the maximum of the positional information detected at two or more detecting points of the detection means, and the minimum value. Moreover, the 3rd scanning aligner by this invention By moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam A detection means to detect the positional information of the 2nd body about the direction of an optical axis of the projection system in two or more detecting points during migration of the 2nd body in the scanning aligner which carries out scan exposure of the 2nd body, It has an alignment means to carry out weighting to the positional information detected at two or more detecting points of the detection means, and to perform alignment of the field and the image surface of a projection system of the request on the 2nd body during migration of the 2nd body. Moreover, the 4th scanning aligner by this invention By moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam A detection means to detect the positional information of the 2nd body about the direction of an optical axis of the projection system at two or more detecting points during migration of the 2nd body in the scanning aligner which carries out scan exposure of the 2nd body, During migration of the 2nd body, it has a setting means to perform a field setup of the 2nd body to the image surface of the projection system based on the detection result of the detection means, and the speed of response when performing a field setup of the 2nd body is changed according to the passing speed of the 2nd body. Moreover, the 5th scanning aligner by this invention By moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam A detection means to detect the concavo-convex information on the exposure side of the 2nd body in the scanning aligner which carries out scan exposure of the 2nd body, It has a setting means to perform a field setup of the exposure side based on the concavo-convex information detected with the detection means in order to perform alignment of the exposure side and the image surface of a projection system of the 2nd body during scan exposure of the exposure side of the 2nd body. This setting means controls a field setup which worsens the alignment precision of the image surface and its exposure side. The 1st scan exposure approach by this invention next, by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam When the inclination of the 2nd body is set up during migration of the 2nd body in the scan exposure

approach which carries out scan exposure of the 2nd body, The speed of response when setting up the inclination of the speed of response and the migration direction of the 2nd body of [ when setting up the inclination of the migration direction of the 2nd body ], and the crossing direction is changed. The 2nd scan exposure approach by this invention moreover, by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam In the scan exposure approach which carries out scan exposure of the 2nd body, in case the inclination of the 2nd body is set up during migration of the 2nd body, the speed of response when setting up the inclination of the migration direction of the 2nd body is changed according to the passing speed of the 2nd body. The 3rd scan exposure approach by this invention moreover, by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam In the scan exposure approach which carries out scan exposure of the 2nd body, while detecting the positional information of the 2nd body about the direction of an optical axis of the projection system in two or more measure points during migration of the 2nd body Based on the maximum of the positional information detected at these two or more detecting points, and the minimum value, the physical relationship of the image surface and the 2nd body of the projection system is adjusted. The 4th scan exposure approach by this invention moreover, by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam In the scan exposure approach which carries out scan exposure of the 2nd body during migration of the 2nd body Weighting is carried out to the positional information which detects the positional information of the 2nd body about the direction of an optical axis of the projection system in two or more detecting points, and is detected at these two or more detecting points, and it is the thing of the field and the image surface of a projection system of the request on the 2nd body which carries out alignment. The 5th scan exposure approach by this invention moreover, by moving the 2nd body to the exposure beam which passed the projection system synchronizing with moving the 1st body to an exposure beam When carrying out scan exposure of the exposure side, performing a field setup of the exposure side based on the concavo-convex information on the exposure side in the scan exposure scan exposure approach which carries out scan exposure of the 2nd body in order to perform alignment of the exposure side and the image surface of a projection system of the 2nd body A field setup which worsens the alignment precision of the image surface and its exposure side is controlled. Next, the scanning aligner of above-mentioned this invention is used for the 1st device manufacture approach by this invention. Moreover, the scan exposure approach of above-mentioned this invention is used for the 2nd device manufacture approach by this invention.

[Procedure amendment 6]
[Document to be Amended] Specification
[Item(s) to be Amended] 0019
[Method of Amendment] Modification
[Proposed Amendment]
[0019]
[Function] In this this invention, in case the mask (12) as the 1st body and the sensitization substrate (5) as the 2nd body are scanned synchronously and the pattern image of a mask (12) is exposed on a sensitization substrate (5), the height of a sensitization substrate (5) is measured using the multipoint measurement means in two or more measure points containing the measure point before the direction of the scan. And it asks for the tilt angle of a sensitization substrate (5) by acquiring multiple-times height information along the direction of a scan, respectively in the measure point of these plurality. Then, in case the pattern image of a mask (12) is exposed to the field to which the tilt angle was called for such, the tilt angle of the field is set up based on the tilt angle for which it asked beforehand. Thereby, the exposure side of a sensitization substrate (5) is set up in parallel with the image surface of projection optics (8) also by the slit scan exposure method.

[Procedure amendment 7]
[Document to be Amended] Specification
[Item(s) to be Amended] 0027
[Method of Amendment] Modification
[Proposed Amendment]
[0027] In this invention, in order to remove these errors, the responsibility of the scanning direction of a leveling device and the responsibility of the non-scanning direction are changed. It is premised on the focal location detection system of the multipoint of an oblique incidence mold as a multipoint measurement means for auto leveling devices in this invention. Moreover, it aims at making maximum of the gap with

each point of the exposure side in the predetermined field, and the image surface of projection optics into min regardless of the average field of the exposure side of the sensitization substrate in the predetermined field in the exposure field of projection optics. Thus, in the predetermined field in the exposure field of projection optics, the exposure field in case the maximum of the gap with almost all the points of the exposure side of a sensitization substrate and the image surface of projection optics is min is called "the good field (Good Field)."

[Procedure amendment 8]
[Document to be Amended] Specification
[Item(s) to be Amended] 0035
[Method of Amendment] Modification
[Proposed Amendment]

[0035] Next, the automatic focus control in this invention is considered. If the concept of the above-mentioned good field (Good Field) is taken in, as shown in drawing 16, precision may get worse by performing equalization processing of the focal location of each measure point in center-section 24a of the exposure field 24, and doubling with the image surface of projection optics the field shown by the average of the focal location. That is, drawing 18 (a) shows field 34A corresponding to the average of the focal location of each measure point of exposure side 5a with the crevice of depth H of a sensitization substrate, and the difference deltaZ3 of the direction of a focus of the field 34A and crevice is large from H/2.

[Procedure amendment 9]
[Document to be Amended] Specification
[Item(s) to be Amended] 0097
[Method of Amendment] Modification
[Proposed Amendment]
[0097]

[Effect of the Invention] According to the 1st field location equipment of this invention, the 1st scanning aligner, the 1st scan exposure approach, etc., in the projection aligner of a slit scan exposure method, the error by the irregularity of the front face of a sensitization substrate, the measurement precision of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the exposure side of a sensitization substrate can be doubled in parallel with high precision to the image surface of projection optics.

[Procedure amendment 10]
[Document to be Amended] Specification
[Item(s) to be Amended] 0099
[Method of Amendment] Modification
[Proposed Amendment]

[0099] Moreover, when a multipoint measurement means changes the location of two or more measure points to one shot field of a sensitization substrate one by one in the process which exposes the pattern of a mask one by one, both leveling precision and a throughput can be improved by using together for example, a division read ahead and a full read ahead. Moreover, according to the 2nd field location equipment of this invention, the 2nd scanning aligner, the 3rd scan exposure approach, etc., in the projection aligner of a slit scan exposure method, the error by the irregularity of the front face of a sensitization substrate, the measurement precision of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the focal location of the exposure side of a sensitization substrate can be correctly doubled to the image surface of projection optics.

[Procedure amendment 11]
[Document to be Amended] Specification
[Item(s) to be Amended] drawing 1
[Method of Amendment] Modification
[Proposed Amendment]

[Drawing 1] It is the block diagram showing the projection aligner of one example of this invention.

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[Translation done.]

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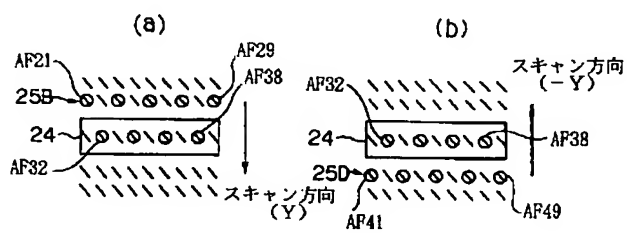
(54)【発明の名称】面位置設定装置

(57)【要約】

【目的】　スリットスキャン露光方式の投影露光装置において、感光基板の露光面を投影光学系の像面に対して高精度に合わせ込む。

【構成】　スリット状の露光フィールド２４に対してウエハをＹ方向に走査して露光を行う場合には、走査方向に対して手前の第２列２５Ｂ内のサンプル点ＡＦ２１～ＡＦ２９及び露光フィールド２４内のサンプル点ＡＦ３２～ＡＦ３８で得られたフォーカス位置の情報からウエハのレベリング及びフォーカシングの制御を行う。また、ウエハを－Ｙ方向に走査して露光を行う場合には、走査方向に対して手前の第４列２５Ｄ内のサンプル点ＡＦ４１～ＡＦ４９及び露光フィールド２４内のサンプル点ＡＦ３２～ＡＦ３８で得られたフォーカス位置の情報からウエハのレベリング及びフォーカシングの制御を行う。



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【特許請求の範囲】

【請求項１】　露光光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して露光用のパターンが形成されたマスクを走査するマスク側ステージと、前記照明領域内の前記マスクのパターンを感光基板上に投影する投影光学系と、前記マスクと同期して前記感光基板を走査する基板側ステージとを有する露光装置に設けられ、前記感光基板の露光面を前記投影光学系の像面に平行に合わせ込むための面位置設定装置であって、
前記感光基板が走査される方向に交差する方向の複数の点を含む複数の計測点において前記感光基板の前記投影光学系の光軸に平行な方向の高さをそれぞれ計測する多点計測手段と、
該多点計測手段の計測結果より前記感光基板の露光面と前記投影光学系の像面との間の傾斜角の差分を求める演算手段と、
前記基板側ステージに設けられ、前記演算手段により求められた前記傾斜角の差分に基づいて、前記感光基板の前記走査の方向の傾斜角及び前記走査の方向に直交する方向の傾斜角を設定する傾斜設定ステージとを有し、
該傾斜設定ステージが前記感光基板の前記走査の方向の傾斜角を設定するときの応答速度と、前記走査の方向に直交する方向の傾斜角を設定するときの応答速度とを異ならしめたことを特徴とする面位置設定装置。

【請求項２】　前記多点計測手段は、前記基板側ステージを介して前記感光基板が走査されているときに、前記基板側ステージの位置基準で前記複数の計測点における前記感光基板の高さをサンプリングすることを特徴とする請求項１記載の面位置設定装置。

【請求項３】　前記多点計測手段は、前記所定形状の照明領域と前記投影光学系に関して共役な露光領域内の複数の点及び前記共役な露光領域内に対して前記感光基板が走査される際の手前の領域内の複数の点よりなる複数の計測点において、前記感光基板の高さをそれぞれ計測することを特徴とする請求項１又は２記載の面位置設定装置。

【請求項４】　前記多点計測手段は、前記感光基板の１つのショット領域へ順次前記マスクのパターンを露光する過程において、順次前記複数の計測点の位置を変化させることを特徴とする請求項１記載の面位置設定装置。

【請求項５】　露光光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して露光用のパターンが形成されたマスクを走査するマスク側ステージと、前記照明領域内の前記マスクのパターンを感光基板上に投影する投影光学系と、前記マスクと同期して前記感光基板を走査する基板側ステージとを有する露光装置に設けられ、前記感光基板の露光面の高さを前記投影光学系の像面に合わせ込むための面位置設定装置であって、
前記所定形状の照明領域と前記投影光学系に関して共役な露光領域及び該露光領域に対して前記感光基板が走査される際の手前の領域よりなる計測領域内の所定の計測点において、前記感光基板の前記投影光学系の光軸に平行な方向の高さを計測する高さ計測手段と、
前記感光基板を走査した際に前記高さ計測手段により得られる複数の高さ計測結果の内の、最大値及び最小値に基づいて前記感光基板の露光面の平均的な高さと前記投影光学系の像面の高さとの差分を求める演算手段と、
前記基板側ステージに設けられ、前記演算手段により求められた前記高さの差分に基づいて、前記感光基板の高さを設定する高さ設定ステージとを有することを特徴とする面位置設定装置。

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【発明の詳細な説明】

【０００１】

【産業状の利用分野】本発明は、例えばスリットスキャン露光方式の投影露光装置のオートフォーカス機構又はオートレベリング機構に適用して好適な面位置設定装置に関する。

【０００２】

【従来の技術】半導体素子、液晶表示素子又は薄膜磁気ヘッド等をフォトリソグラフィ工程で製造する際に、フォトマスク又はレチクル（以下、「レチクル」と総称する）のパターンを感光材が塗布された基板（ウエハ、ガラスプレート等）上に転写する投影露光装置が使用されている。従来の投影露光装置としては、ウエハの各ショット領域を順次投影光学系の露光フィールド内に移動させて、各ショット領域に順次レチクルのパターン像を露光するというステップ・アンド・リピート方式の縮小投影型露光装置（ステッパー）が多く使用されていた。

【０００３】図２０は従来のステッパーの要部を示し、この図２０において、図示省略された照明光学系からの露光光ＥＬのもとで、レチクル５１上のパターンの像が投影光学系５２を介してフォトレジストが塗布されたウエハ５３上の各ショット領域に投影露光される。ウエハ５３は、Ｚレベリングステージ５４上に保持され、Ｚレベリングステージ５４はウエハ側ＸＹステージ５５の上に載置されている。ウエハ側ＸＹステージ５５は、投影光学系５２の光軸ＡＸ１に垂直な平面（ＸＹ平面）内でウエハ５３の位置決めを行い、Ｚレベリングステージ５４は、ウエハ５３の露光面のフォーカス位置（光軸ＡＸ１に平行な方向の位置）及びその露光面の傾斜角を指定された状態に設定する。

【０００４】また、Ｚレベリングステージ５４上に、移動鏡５６が固定されている。外部のレーザ干渉計５７からのレーザビームがその移動鏡５６で反射され、ウエハ側ＸＹステージ５５のＸ座標及びＹ座標がレーザ干渉計５７により常時検出され、これらＸ座標及びＹ座標が主制御系５８に供給されている。主制御系５８は、駆動装置５９を介してウエハ側ＸＹステージ５５及びＺレベリングステージ５４の動作を制御することにより、ステップ・アンド・リピート方式でウエハ５３上の各ショット

領域に順次レチクル５１のパターン像を露光する。

【０００５】この際、レチクル５１上のパターン形成面（レチクル面）とウエハ５３の露光面とは投影光学系５２に関して共役になっている必要があるが、投影倍率が高く、焦点深度が大きい為にレチクル面はあまり変動しない。そこで、従来は一般に、斜め入射型の多点のフォーカス位置検出系によってウエハ５３の露光面が投影光学系５２の像面に焦点深度の範囲内で合致しているかどうか（合焦しているかどうか）のみを検出し、ウエハ５３の露光面のフォーカス位置及び傾斜角の制御を行っていた。

【０００６】従来の多点のフォーカス位置検出系において、露光光ＥＬとは異なりウエハ５３上のフォトレジストを感光させない照明光が、図示省略された照明光源から光ファイバ束６０を介して導かれている。光ファイバ束６０から射出された照明光は、集光レンズ６１を経てパターン形成板６２を照明する。パターン形成板６２を透過した照明光は、レンズ６３、ミラー６４及び照射対物レンズ６５を経てウエハ５３の露光面に投影され、ウエハ５３の露光面にはパターン形成板６２上のパターンの像が光軸ＡＸ１に対して斜めに投影結像される。ウエハ５３で反射された照明光は、集光対物レンズ６６、回転方向振動板６７及び結像レンズ６８を経て受光器６９に受光面に再投影され、受光器６９の受光面には、パターン形成板６２上のパターンの像が再結像される。この場合、主制御系５８は加振装置７０を介して回転方向振動板６７に後述のような振動を与え、受光器６９の多数の受光素子からの検出信号が信号処理装置７１に供給され、信号処理装置７１は、各検出信号を加振装置７０の駆動信号で同期検波して得た多数のフォーカス信号を主制御系５８に供給する。

【０００７】図２１（ｂ）は、パターン形成板６２上に形成された開口パターンを示し、この図２１（ｂ）に示すように、パターン形成板６２上には十字状に９個のスリット状の開口パターン７２－１～７２－９が設けられている。それらの開口パターン７２－１～７２－９はウエハ５３の露光面に対してＸ軸及びＹ軸に対して４５°で交差する方向から照射されるため、ウエハ５３の露光面上の投影光学系５２の露光フィールド内での、それら開口パターン７２－１～７２－９の各投影像ＡＦ１～ＡＦ９は図２１（ａ）に示すような配置になる。図２１（ａ）において、投影光学系５２の円形の照明視野に内接して最大露光フィールド７４が形成され、最大露光フィールド７４内の中央部及び２個の対角線上の計測点ＡＦ１～ＡＦ９にそれぞれスリット状の開口パターンの投影像が投影されている。

【０００８】図２１（ｃ）は、受光器６９の受光面の様子を示し、この図２１（ｃ）に示すように、受光器６９の受光面には十字型に９個の受光素子７５－１～７５－９が配置され、各受光素子７５－１～７５－９の上にはスリット状の開口を有する遮光板（図示省略）が配置されている。そして、図２１（ａ）の各計測点ＡＦ１～ＡＦ９上の像がそれぞれ受光器６９の各受光素子７５－１～７５－９の上に再結像されている。この場合、図２０のウエハ５３の露光面（ウエハ面）で反射された照明光は、集光対物レンズ６６の瞳位置に存在すると共に図２０の紙面にほぼ垂直な軸の回りに振動（回転振動）する回転方向振動板６７に反射されるため、図２１（ｃ）に示すように、受光器６９上では各受光素子７５－１～７５－９上に再結像される投影像の位置がスリット状の開口の幅方向であるＲＤ方向に振動する。

【０００９】また、図２１（ａ）の各計測点ＡＦ１～ＡＦ９上のスリット状の開口の像は、投影光学系５２の光軸に対して斜めに投影されているため、ウエハ５３の露光面のフォーカス位置が変化すると、それら投影像の受光器６９上での再結像位置はＲＤ方向に変化する。従って、信号処理装置７１内で、各受光素子７５－１～７５－９の検出信号をそれぞれ回転方向振動板６７の加振信号で同期検波することで、計測点ＡＦ１～ＡＦ９のフォーカス位置にそれぞれ対応する９個のフォーカス信号が得られる。そして、９個のフォーカス位置から、露光フィールド７４の平均的な面の傾斜角及びその平均的な面のフォーカス位置が求められて主制御系５８に供給され、主制御系５８は、駆動装置５９及びＺレベリングステージ５４を介してウエハ５３の当該ショット領域のフォーカス位置及び傾斜角（レベリング角）を所定の値に設定する。このようにして、ステッパーにおいては、ウエハ５３の各ショット領域においてフォーカス位置及び傾斜角が投影光学系５２の像面に合わせ込まれた状態で、それぞれレチクル５１のパターン像が露光されていた。



【００１０】

【発明が解決しようとする課題】近年、半導体素子等においてはパターンが微細化しているため、投影光学系の解像力を高めることが求められている。解像力を高めるための手法には、露光光の波長の短波長化、又は投影光学系の開口数の増大等の手法があるが、何れの手法を用いる場合でも、従来例と同じ程度の露光フィールドを確保しようとすると、露光フィールドの全面で結像性能（ディストーション、像面湾曲等）を所定の精度に維持することが困難になってきている。そこで現在見直されているのが、所謂スリットスキャン露光方式の投影露光装置である。

【００１１】このスリットスキャン露光方式の投影露光装置では、矩形状又は円弧状等の照明領域（以下、「スリット状の照明領域」という）に対してレチクル及びウエハを相対的に同期して走査しながら、そのレチクルのパターンがウエハ上に露光される。従って、前記スリット状の照明領域と共役な領域内で像が平均化され、ディストーション精度が向上するという利点があった。

【0012】また、従来のレチクルの大きさの主流は6インチサイズであり、投影光学系の投影倍率の主流は1／5倍であったが、半導体素子等の回路パターンの大面積化により、倍率1／5倍のもとでのレチクルの大きさは6インチサイズでは間に合わなくなっている。そのため、投影光学系の投影倍率を例えば1／4倍に変更した投影露光装置を設計する必要がある。そして、このような被転写パターンの大面積化に対して投影光学系の露光フィールド径を小さくする事ができるスリットスキャン露光方式がコスト面に於いても有利である。

【0013】斯かるスリットスキャン露光方式の投影露光装置において、従来のステッパーで用いられていた多点型のフォーカス位置検出系をそのまま適用して、ウエハ上の露光面のフォーカス位置及び傾斜角を計測したとしても、ウエハが所定の方向に走査されているため、実際の露光面を投影光学系の像面に合わせ込むことが困難であるという不都合があった。即ち、従来はスリットスキャン露光方式の投影露光装置において、ウエハのフォーカス位置及び傾斜角を投影光学系の像面に合わせ込むための手法が確率されていなかった。

【0014】本発明は斯かる点に鑑み、スリットスキャン露光方式の投影露光装置において、感光基板の露光面を投影光学系の像面に対して高精度に合わせ込むために使用できるような面位置設定装置を提供することを目的とする。

【0015】

【課題を解決するための手段】本発明の第1の面位置設定装置は、露光光で所定形状の照明領域を照明する照明光学系と、その照明領域に対して露光用のパターンが形成されたマスク（12）を走査するマスク側ステージ（10）と、その照明領域内のマスク（12）のパターンを感光基板（5）上に投影する投影光学系（8）と、マスク（12）と同期して感光基板（5）を走査する基板側ステージ（2）とを有する露光装置に設けられ、感光基板（5）の露光面を投影光学系（8）の像面に平行に合わせ込むための面位置設定装置であって、感光基板（5）が走査される方向に交差する方向の複数の点を含む複数の計測点（AF11～AF59）において感光基板（5）の投影光学系（8）の光軸に平行な方向の高さをそれぞれ計測する多点計測手段（62A，69A）と、この多点計測手段の計測結果より感光基板（5）の露光面と投影光学系（8）の像面との間の傾斜角の差分を求める演算手段（71A）とを有する。

【0016】更に本発明は、基板側ステージ（2）に設けられ、演算手段（71A）により求められたその傾斜角の差分に基づいて、感光基板（5）のその走査の方向（Y方向）の傾斜角及びその走査の方向に直交する方向（X方向）の傾斜角を設定する傾斜設定ステージ（4）を有し、例えば図5に示すように、傾斜設定ステージ（4）が感光基板（5）のその走査の方向（Y方向）の傾斜角$\theta_Y$を設定するときの応答速度と、その走査の方向に直交する方向（X方向）の傾斜角$\theta_X$を設定するときの応答速度とを異ならしめたものである。

【0017】この場合、その多点計測手段は、基板側ステージ（2）を介して感光基板（5）が走査されているときに、基板側ステージ（2）の位置基準でそれら複数の計測点における感光基板（5）の高さをサンプリングしても良い。また、その多点計測手段は、その所定形状の照明領域と投影光学系（8）に関して共役な露光領域（24）内の複数の点及びその共役な露光領域内に対して感光基板（5）が走査される際の手前の領域内の複数の点よりなる複数の計測点において、感光基板（5）の高さをそれぞれ計測するものであっても良い。

【0018】また、その多点計測手段は、感光基板（5）の1つのショット領域へ順次マスク（12）のパターンを露光する過程において、順次それら複数の計測点の位置を変化させることが望ましい。また、本発明による第2の面位置設定装置は、露光光で所定形状の照明領域を照明する照明光学系と、その照明領域に対して露光用のパターンが形成されたマスク（12）を走査するマスク側ステージ（10）と、その照明領域内のマスク（12）のパターンを感光基板（5）上に投影する投影光学系（8）と、マスク（12）と同期して感光基板（5）を走査する基板側ステージ（2）とを有する露光装置に設けられ、感光基板（5）の露光面の高さを投影光学系（8）の像面に合わせ込むための面位置設定装置であって、その所定形状の照明領域と投影光学系（8）に関して共役な露光領域（24）及びこの露光領域に対して感光基板（5）が走査される際の手前の領域よりなる計測領域内の所定の計測点において、感光基板（5）の投影光学系（8）の光軸に平行な方向の高さを計測する高さ計測手段（62A，69A）と、感光基板（5）を走査した際にその高さ計測手段により得られる複数の高さ計測結果の内の、最大値及び最小値に基づいて感光基板（5）の露光面の平均的な高さと投影光学系（8）の像面の高さとの差分を求める演算手段（71A）と、基板側ステージ（2）に設けられ、演算手段（71A）により求められたその高さの差分に基づいて、感光基板（5）の高さを設定する高さ設定ステージ（4）とを有するものである。

【0019】

【作用】斯かる本発明の第1の面位置設定装置においては、マスク（12）及び感光基板（5）を同期して走査して感光基板（5）上にマスク（12）のパターン像を露光する際に、例えばその走査の方向の手前の計測点を含む複数の計測点でその多点計測手段を用いて感光基板（5）の高さを計測する。そして、それら複数の計測点でそれぞれ走査の方向に沿って複数回高さ情報を得ることにより、感光基板（5）の傾斜角を求める。その後、そのように傾斜角が求められた領域にマスク（12）の

パターン像を露光する際に、予め求めた傾斜角に基づいてその領域の傾斜角を設定する。これにより、スリットスキャン露光方式でも感光基板（５）の露光面が投影光学系（８）の像面に平行に設定される。

【００２０】また、本発明ではそのようなレベリングを行う際に、スキャン方向のレベリングの応答速度と、非スキャン方向レベリングの応答速度とが異なっている。これによる作用効果につき説明するため、スリットスキャン露光時のフォーカシング及びレベリングの誤差要因について説明する。スリットスキャン露光方式の露光装置では、以下の誤差が考えられる。

①フォーカスオフセット誤差及び振動誤差

フォーカスオフセット誤差とは、露光面の平均的な面と投影光学系の像面とのフォーカス位置の差であり、振動誤差とは走査露光する際の基板側ステージのフォーカス方向の振動等に起因する誤差である。これについて、オートフォーカス制御だけを行うものとして、ステッパーのように一括露光する場合と、スリットスキャン露光方式で露光する場合とに分けてより詳細に説明する。

【００２１】図１４（ａ）は一括露光する場合、図１４（ｂ）はスリットスキャン露光方式で露光する場合を示す。図１４（ａ）においては、感光基板の露光面５ａの平均的な面３４が投影光学系の像面に合致しているが、位置Ｙａ，Ｙｂ及びＹｃのフォーカス位置はそれぞれ一定の平均的な面３４に対して、－ΔＺ１，０及びΔＺ２だけ異なっている。従って、位置Ｙａ及びＹｂにおけるフォーカスオフセット誤差はそれぞれ－ΔＺ１及びΔＺ２である。

【００２２】一方、図１４（ｂ）の場合には、スキャン方向に対して露光面５ａ上の一連の部分的な平均面３５Ａ，３５Ｂ，３５Ｃ，‥‥が順次投影光学系の像面に合わせ込まれる。従って、各位置Ｙａ，Ｙｂ及びＹｃでのフォーカスオフセット誤差はそれぞれ平均化効果で０となる。しかし、位置Ｙｂ上の像を形成するのに、平均面３５Ｂから平均面３５Ｄまでの高さΔＺＢの間をフォーカス位置が移動するので、位置Ｙｂ上の像は、ΔＺＢだけフォーカス方向にばらつきを持った像になってしまう。同様に、位置Ｙａ及びＹｃ上の像はそれぞれフォーカス方向にΔＺＡ及びΔＺＢだけばらつきを持った像になる。

【００２３】即ち、スリットスキャン露光方式においては、フォーカスオフセット誤差はある一定周波数以下の感光基板面の凹凸に対しほぼ０になるが、基板側ステージのローリング、ピッチング、フォーカス方向（Ｚ軸方向）の振動、低周波空気揺らぎ誤差にオートフォーカス機構及びオートレベリング機構が追従してしまうことによる誤差成分、露光光（ＫｒＦエキシマレーザ光等）の短期の波長変動等が、新たな誤差（振動誤差）を生ずる。

【００２４】②フォーカス追従誤差、空気揺らぎ誤差、ステージ振動誤差

①で言及した振動誤差の内の代表的な例であり、これらはオートフォーカス機構及びオートレベリング機構の応答周波数に依存するが、更に以下の誤差に分類できる。(1) 制御系で制御出来ない高周波ステージ振動誤差、露光光（ＫｒＦエキシマレーザ光等）の短期の波長変動誤差等、(2) 空気揺らぎ誤差の中で、基板側ステージが追従してしまう低周波空気揺らぎ誤差等、(3) フォーカス位置検出系又は傾斜角検出系の測定結果には含まれるが、基板側ステージが追従しないので、フォーカス誤差にならない測定誤差等。

【００２５】③感光基板の露光面の凹凸による誤差

この誤差は、投影光学系による露光フィールドが２次元的な面単位であり、感光基板の露光面でのフォーカス位置の計測を有限個の計測点で且つスリットスキャン露光時に行うことに起因する誤差であり、以下の２つの誤差に分類できる。

(1) 例えば図１５（ａ）及び（ｂ）に示すように、感光基板の露光面５ａ上の多点でフォーカス位置を計測して位置合わせ対象面（フォーカス面）３６Ａ及び３６Ｂを求める場合の計測点の位置に対する演算方法に起因する、そのフォーカス面３６Ａと理想フォーカス面とのずれの誤差、(2) スキャン速度とオートフォーカス機構及びオートレベリング機構の追従速度との差、フォーカス位置検出系の応答速度等による誤差。

【００２６】この場合、フォーカス位置を投影光学系の像面に合わせる場合の応答速度（フォーカス応答）は、図１５（ｃ）に示すような時間遅れ誤差と、図１５（ｄ）に示すようなサーボゲインとにより決定される。即ち、図１５（ｃ）において、曲線３７Ａは、感光基板の露光面５ａの一連の部分領域を順次投影光学系の像面に合わせるためのフォーカス方向用の駆動信号（目標フォーカス位置信号）を示し、曲線３８Ａは、露光面５ａの一連の部分領域のフォーカス方向への移動量を駆動信号に換算して得られた信号（追従フォーカス位置信号）を示す。曲線３７Ａに対して曲線３８Ａは一定の時間だけ遅れている。同様に、図１５（ｄ）において、曲線３７Ｂは、感光基板の露光面５ａの一連の部分領域の目標フォーカス位置信号、曲線３８Ｂは、露光面５ａの一連の部分領域の追従フォーカス位置信号であり、曲線３７Ｂに対して曲線３８Ｂの振幅（サーボゲイン）は一定量だけ小さくなっている。

【００２７】本発明の第１の面位置設定装置では、これらの誤差を取り除く為に、レベリング機構のスキャン方向の応答性と非スキャン方向の応答性とを変えている。本発明におけるオートレベリング機構用の多点計測手段としては、斜入射型の多点のフォーカス位置検出系を前提とする。また、投影光学系の露光フィールド内の所定の領域での感光基板の露光面の平均的な面を考慮するのではなく、その所定の領域での露光面の各点と投影光学

系の像面とのずれの最大値を最小にすることを目標とする。このように、投影光学系の露光フィールド内の所定の領域において、感光基板の露光面のほぼ全ての点と投影光学系の像面とのずれの最大値が最小である場合の露光フィールドを「良好なフィールド（Good Field）」と呼ぶ。

【0028】先ず、図１６に示すように、スリット状の照明領域と投影光学系に関して共役なスリット状の露光フィールド２４内にフォーカス位置の多数の計測点（不図示）があると仮定する。図１６において、感光基板上の１つのショット領域$SA_{ij}$をスリット状の露光フィールド２４に対してＹ方向に速度$V/\beta$で走査するものとして、ショット領域$SA_{ij}$のスキャン方向の幅をＷＹ、非スキャン方向の幅をＷＸ、露光フィールド２４のスキャン方向の幅をＤとする。また、露光フィールド２４内の中心領域２４ａ内の多数の計測点でのフォーカス位置を平均化することにより、露光フィールド２４の中心点での平均的な面のフォーカス位置を求め、露光フィールド２４のスキャン方向の両端の計測領域２４ｂ，２４ｃ内の計測点でのフォーカス位置より最小自乗近似に基づいて平均的な面のスキャン方向の傾斜角$\theta_Y$を求め、露光フィールド２４の非スキャン方向の両端の計測領域２４ｂ，２４ｃ内の計測点でのフォーカス位置より最小自乗近似に基づいて平均的な面の非スキャン方向の傾斜角$\theta_X$を求めるものとする。また、スキャン方向のレベリングの応答周波数をｆｍ［Ｈｚ］、非スキャン方向のレベリングの応答周波数をｆｎ［Ｈｚ］として、ｆm及びｆｎの値を独立に設定する。

【0029】そして、感光基板上のショット領域$SA_{ij}$のスキャン方向の周期的な曲がりの周期を、スキャン方向の幅ＷＹ（非スキャン方向も同様の曲がり周期に設定する）との比の値として曲がりパラメータＦで表し、その周期的な曲がりがあるときの露光フィールド２４内の各計測点でのフォーカス誤差を、スキャンした場合のフォーカス誤差の平均値の絶対値と、スキャンした場合のフォーカス誤差の振幅の１／３との和で表す。また、曲がりパラメータＦの周期的な曲がりの振幅を１に規格化し、曲がりパラメータがＦであるときの、それら各計測点でのフォーカス誤差の内の最大値を示す誤差パラメータＳを、曲がりパラメータＦに対する比率として表す。即ち、次式が成立している。

Ｆ＝曲がりの周期／ＷＹ　（1）

Ｓ＝フォーカス誤差の最大値／Ｆ　（2）

【0030】図１７（ａ）は、スキャン方向のレベリングの応答周波数ｆｍ、及び非スキャン方向のレベリングの応答周波数ｆｎが等しく且つ大きい場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ１は非スキャン方向での誤差パラメータＳ、曲線Ｂ１は非スキャン方向の誤差パラメータＳ中の通常のフォーカス誤差の平均値の絶対値、曲線Ａ２はスキャン方向での誤差パラメータＳ、曲線Ｂ２はスキャン方向の誤差パラメータＳ中の通常のフォーカス誤差の平均値を示す。曲線Ａ１及び曲線Ａ２がそれぞれより現実的なフォーカス誤差を現わしている。メータＦの値が小さく露光面の凹凸の周期が小さいときには、スキャン方向のレベリング制御の追従性は悪く（曲線Ａ２）、凹凸の周期が大きくなるにつれて、スキャン方向のレベリング制御が曲がりに追従するようになることが分かる。また、非スキャン方向に対してはスキャン方向の様に逐次フォーカス位置が変わらない為、曲がりの周期が大きくなっても、スキャン方向の追従性より悪い（曲線Ａ１）。以上のように、パラメータＳが０．５以下になるようにフォーカス誤差がなることが望ましいが、スキャン方向及び非スキャン方向共に全体としてフォーカス誤差が大きい。

【0031】一方、図１７（ｂ）は、スキャン方向のレベリングの応答周波数ｆｍが非スキャン方向のレベリングの応答周波数ｆｎより大きく、且つ両応答周波数ｆｍ及びｆｎが小さい場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ３は非スキャン方向での誤差パラメータＳ、曲線Ｂ３は非スキャン方向の通常のフォーカス誤差の平均値の絶対値、曲線Ａ４はスキャン方向での誤差パラメータＳ、曲線Ｂ４はスキャン方向での通常のフォーカス誤差の平均値の絶対値を示す。図１７（ａ）と図１７（ｂ）との比較より、ほぼ完全応答（図１７（ａ））の場合よりも応答周波数が小さい（図１７（ｂ））場合の方が、誤差パラメータＳが０．５に近くなっており、フォーカス誤差は小さいことが分かる。これは、感光基板上の細かい凸凹にオートレベリング機構が追従すると、スリット状の露光フィールド２４内で精度が悪化する点が発生するためである。但し、応答周波数を小さくし過ぎると、低周波の凸凹部まで追従できなくなるため、応答周波数は適当な値に設定する必要がある。

【0032】また、図１７（ｂ）の例では、スキャン方向のレベリングの応答周波数ｆｍが非スキャン方向のレベリングの応答周波数ｆｎより高く設定されている。これは、同じ曲がりパラメータＦの凹凸であっても、スキャン方向ではスリット幅に応じて実質的に周期が短くなるため、良好に露光面の凹凸に追従するための応答周波数は、非スキャン方向よりもスキャン方向で高くする必要があるためである。

【0033】また、オートレベリング機構用の多点計測手段が、その所定形状の照明領域と投影光学系（８）に関して共役な露光領域（２４）内の複数の点及びその共役な露光領域内に対して感光基板（５）が走査される際の手前の領域内の複数の点よりなる複数の計測点において、感光基板（５）の高さをそれぞれ計測する場合には、手前の計測点において部分的にフォーカス位置の先読みが行われる。これを「分割先読み」と呼ぶ。従って、全部の計測点で先読みを行う手法（完全先読み）に

比べて、露光までに多点計測手段でフォーカス位置を読み取る際の長さ（助走距離）が短縮される。

【００３４】また、その多点計測手段が、感光基板（５）の１つのショット領域へ順次マスク（１２）のパターンを露光する過程において、順次それら複数の計測点の位置を変化させる場合には、例えばそのショット領域の端部では分割先読みを行い、そのショット領域の中央部以降では完全先読みを行い、露光位置検出部でオープン制御の確認を行う。これにより、レベリング精度を高精度に維持した状態で、ショット領域の端部での助走距離を短縮して露光のスループットを高めることができる。

【００３５】次に、本発明の第２の面位置設定装置におけるオートフォーカス制御について検討する。上述の良好なフィールド（Good Field）の概念を取り入れると、図１６に示すように、露光フィールド２４の中央部２４ａ内の各計測点のフォーカス位置の平均化処理を行って、そのフォーカス位置の平均値で示される面を投影光学系の像面に合わせるのでは、精度が悪化する可能性がある。即ち、図１８（ａ）は、感光基板の深さＨの凹部のある露光面５ａの各計測点のフォーカス位置の平均値に対応する面３４Ａを示し、その面３４Ａと凹部とのフォーカス方向の差ΔＺ３は、Ｈ／２より大きくなっている。

【００３６】これに対して本発明においては、露光面５ａ上の所定の計測領域内の各計測点のフォーカス位置の最大値と最小値とを求め、それら最大値と最小値との中間のフォーカス位置に対応する面を投影光学系の像面に合わせ込むようにする。図１８（ｂ）は、感光基板の深さＨの凹部のある露光面５ａにおける、各計測点のフォーカス位置の内の最大値$Z_{max}$と最小値$Z_{min}$との中間のフォーカス位置に対応する面３４Ｂを示し、面３４Ｂのフォーカス位置$Z_{34B}$は次のように表すことができる。

$$Z_{34B} = (Z_{max} + Z_{min}) / 2 \quad (3)$$

【００３７】その後、その面３４Ｂが投影光学系の像面に合わせ込まれる。また、面３４Ｂと露光面５ａの表面とのフォーカス方向の差ΔＺ４と、面３４Ｂとその凹部とのフォーカス方向の差ΔＺ５とは、それぞれほぼＨ／２になっている。即ち、図１８（ａ）の面３４Ａに比べて図１８（ｂ）の面３４Ｂの方が、露光面５ａ上の各点におけるフォーカス位置の誤差の最大値が小さくなるため、良好なフィールド（Good Field）の概念上では、本発明により感光基板の露光面をより高精度に投影光学系の像面に合わせ込むことができる。

【００３８】更に、図１７（ａ）のように、スキャン方向のレベリングの応答周波数ｆｍと非スキャン方向のレベリングの応答周波数ｆｎとを等しく且つ大きくしてオートレベリング制御を行うと同時に、図１８（ａ）の平均化処理に基づくオートフォーカス制御又は図１８（ｂ）の最大値と最小値との平均値に基づくオートフォーカス制御を施した場合の、曲がりパラメータＦに対する誤差パラメータＳの特性をそれぞれ図１９（ａ）及び（ｂ）に示す。即ち、平均化処理に基づく図１９（ａ）において、曲線Ａ５及びＢ５はそれぞれ非スキャン方向の誤差パラメータＳ、曲線Ａ６及びＢ６はそれぞれスキャン方向の誤差パラメータＳを表す。また、最大値と最小値との平均値に基づく図１９（ｂ）において、曲線Ａ７及びＢ７はそれぞれ非スキャン方向の誤差パラメータＳ、曲線Ａ８及びＢ８はそれぞれスキャン方向の誤差パラメータＳを表す。

【００３９】図１９（ｂ）より明かなように、最大値と最小値との平均値に基づいてオートフォーカス制御を施した場合には、全ての曲がりパラメータＦ、即ちあらゆる周波数帯において、誤差パラメータＳの値が０．５に近くなっていると共に、平均化処理に基づいてオートフォーカス制御を施した場合に比べてフォーカス誤差の最大値が小さくなっている。

【００４０】また、図１５（ａ）及び（ｂ）に戻り、所定の計測領域内の計測点で得られたフォーカス位置の最大値と最小値との平均値に基づいてオートフォーカス制御のみを施した場合には、図１５（ａ）に示すように、振幅２・ΔＺａの曲がりを有する露光面５ａに対して、最大値とのフォーカス位置の差がΔＺａの面３６Ａが投影光学系の像面に合わせ込まれる。一方、振幅２・ΔＺａの曲がりを有する露光面５ａに対して、単にそれら計測点で得られたフォーカス位置の平均値に基づいてオートフォーカス制御を行うと共に、得られたフォーカス位置の最小自乗近似に基づいてオートレベリング制御を行うと、図１５（ｂ）に示すように、振幅ΔＺｃ（＞２・ΔＺａ）の範囲内で最大値からのフォーカス位置の差がΔＺｂ（＞ΔＺａ）の面３６Ｂが投影光学系の像面に合わせ込まれることがある。従って、オートレベリング機構を使用する場合でも使用しない場合でも、得られたフォーカス位置の最大値と最小値との平均値に基づいてオートフォーカス制御を行う方がフォーカス誤差が小さくなる。

【００４１】なお、本発明では、（フォーカス位置の最大値$Z_{max}$＋フォーカス位置の最小値$Z_{min}$）／２で定まる面を像面に合わせ込むように制御しているが、デバイス工程によっては感光基板の露光面５ａの凸部又は凹部の何れかの焦点深度が要求される場合もある。従って、所定の係数Ｍ及びＮを用いて、次式のような比例配分で定まるフォーカス位置$Z_{MN}$の面を像面に合わせるような制御を行うことが望ましい。

$$Z_{MN} = (M \cdot Z_{max} + N \cdot Z_{min}) / (M+N) \quad (4)$$

【００４２】

【実施例】以下、本発明の一実施例につき図面を参照し

て説明する。本実施例は、スリットスキャン露光方式の投影露光装置のオートフォーカス機構及びオートレベリング機構に本発明を適用したものである。図１は本実施例の投影露光装置を示し、この図１において、図示省略された照明光学系からの露光光ＥＬによる矩形の照明領域（以下、「スリット状の照明領域」という）によりレチクル１２上のパターンが照明され、そのパターンの像が投影光学系８を介してウエハ５上に投影露光される。この際、露光光ＥＬのスリット状の照明領域に対して、レチクル１２が図１の紙面に対して手前方向（又は向こう側）に一定速度Ｖで走査されるのに同期して、ウエハ５は図１の紙面に対して向こう側（又は手前方向）に一定速度Ｖ／β（１／βは投影光学系８の縮小倍率）で走査される。

【００４３】レチクル１２及びウエハ５の駆動系について説明するに、レチクル支持台９上にＹ軸方向（図１の紙面に垂直な方向）に駆動自在なレチクルＹ駆動ステージ１０が載置され、このレチクルＹ駆動ステージ１０上にレチクル微小駆動ステージ１１が載置され、レチクル微小駆動ステージ１１上にレチクル１２が真空チャック等により保持されている。レチクル微小駆動ステージ１１は、投影光学系８の光軸に垂直な面内で図１の紙面に平行なＸ方向、Ｙ方向及び回転方向（θ方向）にそれぞれ微小量だけ且つ高精度にレチクル１２の位置制御を行う。レチクル微小駆動ステージ１１上には移動鏡２１が配置され、レチクル支持台９上に配置された干渉計１４によって、常時レチクル微小駆動ステージ１１のＸ方向、Ｙ方向及びθ方向の位置がモニターされている。干渉計１４により得られた位置情報Ｓ１が主制御系２２Ａに供給されている。

【００４４】一方、ウエハ支持台１上には、Ｙ軸方向に駆動自在なウエハＹ軸駆動ステージ２が載置され、その上にＸ軸方向に駆動自在なウエハＸ軸駆動ステージ３が載置され、その上にＺレベリングステージ４が設けられ、このＺレベリングステージ４上にウエハ５が真空吸着によって保持されている。Ｚレベリングステージ４上にも移動鏡７が固定され、外部に配置された干渉計１３により、Ｚレベリングステージ４のＸ方向、Ｙ方向及びθ方向の位置がモニターされ、干渉計１３により得られた位置情報も主制御系２２Ａに供給されている。主制御系２２Ａは、ウエハ駆動装置２２Ｂ等を介してウエハＹ軸駆動ステージ２、ウエハＸ軸駆動ステージ３及びＺレベリングステージ４の位置決め動作を制御すると共に、装置全体の動作を制御する。

【００４５】また、ウエハ側の干渉計１３によって計測される座標により規定されるウエハ座標系と、レチクル側の干渉計１４によって計測される座標により規定されるレチクル座標系の対応をとるために、Ｚレベリングステージ４上のウエハ５の近傍に基準マーク板６が固定されている。この基準マーク板６上には各種基準マークが形成されている。これらの基準マークの中にはＺレベリングステージ４側に導かれた照明光により裏側から照明されている基準マーク、即ち発光性の基準マークも設けられている。

【００４６】本例のレチクル１２の上方には、基準マーク板６上の基準マークとレチクル１２上のマークとを同時に観察するためのレチクルアライメント顕微鏡１９及び２０が装備されている。この場合、レチクル１２からの検出光をそれぞれレチクルアライメント顕微鏡１９及び２０に導くための偏向ミラー１５及び１６が移動自在に配置され、露光シーケンスが開始されると、主制御系２２Ａからの指令のもとで、ミラー駆動装置１７及び１８によりそれぞれ偏向ミラー１５及び１６は待避される。

【００４７】図１のスリットスキャン方式の投影露光装置に、図２０及び図２１を参照して説明した従来方式の斜め入射型の多点フォーカス位置検出系を装着する。但し、本例の多点フォーカス位置検出系は、計測点の個数が従来例よりも多いと共に、計測点の配置が工夫されている。図２（ｂ）は、図２１（ｂ）の従来のパターン形成板６２に対応する本例のパターン形成板６２Ａを示し、図２（ｂ）に示すように、パターン形成板６２Ａの第１列目には９個のスリット状の開口パターン７２－１１～７２－１９が形成され、第２列目～第５列目にもそれぞれ９個の開口パターン７２－１２～７２－５９が形成されている。即ち、パターン形成板６２Ａには、合計で４５個のスリット状の開口パターンが形成されており、これらのスリット状の開口パターンの像が図１のウエハ５の露光面上にＸ軸及びＹ軸に対して斜めに投影される。

【００４８】図２（ａ）は、本例の投影光学系８の下方のウエハ５の露光面を示し、この図２（ａ）において、投影光学系８の円形の照明視野２３に内接するＸ方向に長い矩形の露光フィールド２４内に図１のレチクル１２のパターンが露光され、この露光フィールド２４に対してＹ方向にウエハ５が走査（スキャン）される。本例の多点フォーカス位置検出系により、露光フィールド２４のＹ方向の上側のＸ方向に伸びた第１列の９個の計測点ＡＦ１１～ＡＦ１９、第２列の計測点ＡＦ２１～ＡＦ２９、露光フィールド２４内の第３列の計測点ＡＦ３１～ＡＦ３９、露光フィールド２４のＹ方向の下側の第４列の計測点ＡＦ４１～ＡＦ４９及び第５列の計測点ＡＦ５１～ＡＦ５９にそれぞれスリット状の開口パターンの像が投影される。

【００４９】図２（ｃ）は、本例の多点フォーカス位置検出系の受光器６９Ａを示し、この受光器６９Ａ上に第１列目には９個の受光素子７５－１１～７５－１９が配置され、第２列目～第５列目にもそれぞれ９個の受光素子７５－１２～７５－５９が配置されている。即ち、受光器６９Ａには、合計で４５個の受光素子が配列されて

おり、各受光素子上にはスリット状の絞り（図示省略）が配置されている。また、それら受光素子７５－１１～７５－５９上にそれぞれ図２（ａ）の計測点ＡＦ１１～ＡＦ５９に投影されたスリット状の開口パターンの像が再結像される。そして、ウエハ５の露光面で反射された光を、図２０の回転方向振動板６７に対応する振動板で回転振動することで、受光器６９Ａ上では再結像された各像の位置が絞りの幅方向であるＲＤ方向に振動する。

【００５０】各受光素子７５－１１～７５－５９の検出信号が信号処理装置７１Ａに供給され、信号処置装置７１Ａではそれぞれの検出信号を回転振動周波数の信号で同期検波することにより、ウエハ上の各計測点ＡＦ１１～ＡＦ５９のフォーカス位置に対応する４５個のフォーカス信号を生成し、これら４５個のフォーカス信号の内の所定のフォーカス信号より後述のように、ウエハの露光面の傾斜角（レベリング角）及び平均的なフォーカス位置を算出する。これら計測されたレベリング角及びフォーカス位置は図１の主制御系２２Ａに供給され、主制御系２２Ａは、その供給されたレベリング角及びフォーカス位置に基づいて駆動装置２２Ｂ及びＺレベリングステージ４を介してウエハ５のレベリング角及びフォーカス位置の設定を行う。

【００５１】従って、本例では図２（ａ）に示す４５個の全ての計測点ＡＦ１１～ＡＦ５９のフォーカス位置を計測することができる。但し、本例では、図３に示すように、ウエハのスキャン方向に応じてそれら４５個の計測点中で実際にフォーカス位置を計測する点（以下、「サンプル点」という）の位置を変えている。一例として、図３（ａ）に示すように、露光フィールド２４に対してＹ方向にウエハをスキャンする場合で、且つ後述のような分割先読みを行う場合には、第２列２５Ｂの計測点中の奇数番目の計測点ＡＦ２１，ＡＦ２３，‥‥，ＡＦ２９及び露光フィールド２４内の偶数番目の計測点ＡＦ３２，ＡＦ３４，‥‥，ＡＦ３８がサンプル点となる。また、図３（ｂ）に示すように、露光フィールド２４に対して－Ｙ方向にウエハをスキャンする場合で、且つ後述のような分割先読みを行う場合には、第４列２５Ｄの計測点中の奇数番目の計測点ＡＦ４１，ＡＦ４３，‥‥，ＡＦ４９及び露光フィールド２４内の偶数番目の計測点ＡＦ３２，ＡＦ３４，‥‥，ＡＦ３８がサンプル点となる。

【００５２】更に、スリットスキャン露光時のフォーカス位置の計測結果は、ウエハ側のステージの移動座標に応じて逐次変化していくため、それらフォーカス位置の計測結果は、ステージのスキャン方向の座標及び非スキャン方向の計測点の座標よりなる２次元のマップとして図１の主制御系２２Ａ内の記憶装置に記憶される。このように記憶された計測結果を用いて、露光時のウエハのフォーカス位置及びレベリング角が算出される。そして、実際に図１のＺレベリングステージ４を駆動してウエハの露光面のフォーカス位置及びレベリング角を設定する場合は、計測結果に従ってオープンループ制御によりＺレベリングステージ４の動作が制御される。この場合、予め計測された結果に基づいて露光フィールド２４内での露光が行われる。即ち、図４（ａ）に示すように、例えば第２列２５Ｂの計測点の所定のサンプリング点でウエハ上の領域２６のフォーカス位置の計測が行われ、その後図４（ｂ）に示すようにウエハ上の領域２６が露光フィールド２４内に達したときに、図４（ａ）での計測結果に基づいて、ウエハ上の領域２６のフォーカシング及びレベリング制御が行われる。

【００５３】図５は本例のＺレベリングステージ４及びこの制御系を示し、この図５において、Ｚレベリングステージ４の上面部材は下面部材上に３個の支点２８Ａ～２８Ｃを介して支持されており、各支点２８Ａ～２８Ｃはそれぞれフォーカス方向に伸縮できるようになっている。各支点２８Ａ～２８Ｃの伸縮量を調整することにより、Ｚレベリングステージ４上のウエハ５の露光面のフォーカス位置、スキャン方向の傾斜角$\theta_Y$及び非スキャン方向の傾斜角$\theta_X$を所望の値に設定することができる。各支点２８Ａ～２８Ｃの近傍にはそれぞれ、各支点のフォーカス方向の変位量を例えば０．０１μｍ程度の分解能で計測できる高さセンサー２９Ａ～２９Ｃが取り付けられている。なお、フォーカス方向（Ｚ方向）への位置決め機構として、よりストロークの長い高精度な機構を別に設けても良い。

【００５４】Ｚレベリングステージ４のレベリング動作を制御するために、主制御系２２Ａはフィルタ部３０Ａ及び３０Ｂにそれぞれ刻々に変化する非スキャン方向の設定すべき傾斜角$\theta_X$及びスキャン方向の設定すべき傾斜角$\theta_Y$を供給する。フィルタ部３０Ａ及び３０Ｂはそれぞれ異なるフィルタ特性でフィルタリングして得られた傾斜角を演算部３１に供給し、主制御系２２Ａは演算部３１にはウエハ５上の露光対象とする領域の座標Ｗ（Ｘ，Ｙ）を供給する。演算部３１は、座標Ｗ（Ｘ，Ｙ）及び２つの傾斜角に基づいて駆動部３２Ａ～３２Ｃに設定すべき変位量の情報を供給する。各駆動部３２Ａ～３２Ｃにはそれぞれ高さセンサー２９Ａ～２９Ｃから支点２９Ａ～２９Ｃの現在の高さの情報も供給され、各駆動部３２Ａ～３２Ｃはそれぞれ支点２９Ａ～２９Ｃの高さを演算部３１に設定された高さに設定する。

【００５５】これにより、ウエハ５の露光面のスキャン方向の傾斜角及び非スキャン方向の傾斜角がそれぞれ所望の値に設定されるが、この際にフィルタ部３０Ａ及び３０Ｂの特性の相違により、スキャン方向のレベリングの応答周波数ｆｍ［Ｈｚ］が非スキャン方向のレベリングの応答速度ｆｎ［Ｈｚ］よりも高めに設定されている。一例としてスキャン方向のレベリングの応答周波数ｆｍは１０Ｈｚ、非スキャン方向のレベリングの応答速度ｆｎは２Ｈｚである。

【0056】また、支点28A，28B及び28Cが配置されている位置をそれぞれ駆動点TL1，TL2及びTL3と呼ぶと、駆動点TL1及びTL2はY軸に平行な1直線上に配置され、駆動点TL3は駆動点TL1とTL2との垂直2等分線上に位置している。そして、投影光学系によるスリット状の露光フィールド24が、ウエハ5上のショット領域$SA_{ij}$上に位置しているものとすると、本例では、支点28A～28Cを介してウエハ5のレベリング制御を行う際に、そのショット領域$SA_{ij}$のフォーカス位置は変化しない。従って、レベリング制御とフォーカス制御とが分離した形で行われるようになっている。また、ウエハ5の露光面のフォーカス位置の設定は、3個の支点28A～28Cを同じ量だけ変位させることにより行われる。

【0057】次に、本例のレベリング動作及びフォーカシング動作につき詳細に説明する。先ず、レベリング用の傾斜角及びフォーカシング用のフォーカス位置の算出法を示す。

（A）傾斜角の算出法

図4に示すように、各列の計測点において非スキャン方向のm番目のサンプル点のX座標を$X_m$、スキャン方向のn番目のサンプル点のY座標を$Y_n$として、X座標$X_m$及びY座標$Y_n$のサンプル点で計測されたフォーカス位置の値をAF（$X_m$，$Y_n$）で表す。また、非スキャン方向のサンプル数をM、スキャン方向のサンプリング数をNとして、次の演算を行う。但し、和演算$\Sigma_m$は添字mに関する1～Mまでの和を表す。

【0058】

$$SX=\Sigma_m X_m,\ SX2=\Sigma_m X_m^2,\ SMZ=\Sigma_m AF(X_m, Y_n),$$
$$SXZ=\Sigma_m (AF(X_m, Y_n)\cdot X_m) \quad (5)$$

同様に、和演算$\Sigma_n$が添字nに関する1～Nまでの和を表すものとして、次の演算を行う。

$$SY=\Sigma_n Y_n,\ SY2=\Sigma_n Y_n^2,\ SNZ=\Sigma_n AF(X_m, Y_n),$$
$$SYZ=\Sigma_n (AF(X_m, Y_n)\cdot Y_n) \quad (6)$$

【0059】そして、（5）式及び（6）式を用いて次の演算を行う。

$$An=(SX\cdot SMZ-M\cdot SXZ)/(SX^2-M\cdot SX2) \quad (7)$$
$$Am=(SY\cdot SNZ-N\cdot SYZ)/(SY^2-N\cdot SY2) \quad (8)$$

次に、各Anより、最小自乗近似によりスキャン方向のn番目のサンプル点における非スキャン方向（X方向）の傾斜角AL（$Y_n$）を求め、各Amより、最小自乗近似により非スキャン方向のm番目のサンプル点におけるスキャン方向（Y方向）の傾斜角AL（$X_m$）を求める。その後、次のような平均化処理により非スキャン方向の傾斜角$\theta_X$及びスキャン方向の傾斜角$\theta_Y$を求める。

$$\theta_X=(\Sigma_n AL(Y_n))/N \quad (9)$$
$$\theta_Y=(\Sigma_m AL(X_m)) \quad (10)$$

【0060】（B）フォーカス位置算出法

フォーカス位置の算出法には平均化処理法と最大最小検出法とがあり、本例では最大最小検出法でフォーカス位置を算出する。参考のため、平均化処理法では、上述のフォーカス位置の値AF（$X_m$，$Y_n$）を用いて、次式よりウエハ5の露光面の全体としてのフォーカス位置〈AF〉を計算する。

$$\langle AF\rangle=(\Sigma_n \Sigma_m AF(X_m, Y_n))/(M\cdot N) \quad (11)$$

【0061】次に、最大最小検出法では、最大値及び最小値を表す関数をそれぞれMax( )及びMin( )として、次式よりウエハ5の露光面の全体としてのフォーカス位置AF′を計算する。

$$AF'=(\mathrm{Max}(AF(X_m, Y_n))+\mathrm{Min}(AF(X_m, Y_n))/2 \quad (12)$$

そして、図4（b）に示すように、計測された領域26が露光フィールド24に達したときには、（9）式、（10）式、（12）式の検出結果$\theta_X$，$\theta_Y$及びAF′に基づいて、図5の3個の支点28A～28Cがそれぞれ高さセンサー29A～29Cの計測結果を基準としてオープンループで駆動される。具体的に、オートフォーカス制御は、3個の支点28A～28Cを同時に駆動することにより実行され、オートレベリング制御は、図5に示す露光フィールド24内のフォーカス位置が変化しないように実行される。

【0062】即ち、図5において、露光フィールド24の中心点と支点28A，28BのX方向の間隔を$X_1$、露光フィールド24の中心点と支点28CのX方向の間隔を$X_2$、露光フィールド24の中心点と支点28AのY方向の間隔を$Y_1$、露光フィールド24の中心点と支点28BのY方向の間隔を$Y_2$として、非スキャン方向の傾斜角$\theta_X$の結果に基づき、支点28A，28Bと支点28Cとにそれぞれ$X_1$：$X_2$との比で逆方向の変位が与えられ、スキャン方向の傾斜角$\theta_Y$の結果に基づき、支点28Aと支点28Bとにそれぞれ$Y_1$：$Y_2$との比で逆方向の変位が与えられる。

【0063】また、上記処理法では、フォーカス位置及び傾斜角が露光装置に応じて刻々変化するので実際のフォーカス位置の計測値を補正する必要がある。図6（a）は、或るフォーカス位置の計測点（AF点）でウエハの露光面5a上の領域26の全体としてのフォーカス位置及び傾斜角を計測している状態を示し、図6（a）の状態では、図5の各駆動点TL1～TL3にある支点のフォーカス方向の駆動量〈TL1〉，〈TL2〉及び〈TL3〉はそれぞれ0（基準位置）であると

する。そして、その領域２６が図６（ｂ）に示すように、露光フィールド内の露光点に達したときには、露光のためにそれら駆動量はそれぞれ、〈ＴＬ１〉＝ａ，〈ＴＬ２〉＝ｂ，〈ＴＬ３〉＝ｃ、に設定される。この場合、フォーカス位置の計測点（ＡＦ点）で計測されている領域２６Ａのフォーカス位置は、図６（ａ）の場合に比べてΔＦだけ変化しているが、このΔＦの変化量には各駆動点ＴＬ１〜ＴＬ３における駆動量の影響が含まれているため、次に領域２６Ａの露光を行う場合には、図６（ｂ）の状態での各駆動点ＴＬ１〜ＴＬ３の駆動量を補正する形でレベリング及びフォーカシングを行う必要がある。

【００６４】即ち、領域２６に関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角をそれぞれ$F_1$、$\theta_{1X}$及び$\theta_{1Y}$として、領域２６Ａに関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角をそれぞれ$F_n'$、$\theta_{nX}'$及び$\theta_{nY}'$とする。また、フォーカス位置の計測点（ＡＦ点）と露光点とのＸ方向及びＹ方向の間隔をそれぞれΔＸ及びΔＹとすると、フォーカス位置の補正量ΔＦ１は次のようになる。

$\Delta F1 = -F_1 - \theta_{1X}\cdot\Delta X - \theta_{1Y}\cdot\Delta Y$　（１３）

【００６５】その補正量ΔＦ１を用いると、領域２６Ａに関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角のそれぞれの補正後の値$F_n$、$\theta_{nX}$及び$\theta_{nY}$は次のようになる。

$F_n = F_n' + \Delta F1$　（１４）

$\theta_{nX} = \theta_{nX}' - \theta_{1X}$　（１５）

$\theta_{nY} = \theta_{nY}' - \theta_{1Y}$　（１６）

また、ウエハ５の露光面の高周波の凸凹面に対しては追従しない様に応答性を管理する必要がある。即ち、ウエハ５の走査速度が変わった場合も、ステージ位置に対応した応答が要求されるので、計測されたフォーカス位置及び傾斜角を高速フーリエ変換（ＦＦＴ）用の数値フィルターで管理するか、図５の３個の支点２８Ａ〜２８Ｃの駆動部のサーボゲインを速度に応じて可変できる機構にする。但し、ＦＦＴ用の数値フィルターは予備スキャンが必要で、サーボゲインは位相遅れがあるので、これらを考慮した機構が必要である。

【００６６】（Ｃ）サーボゲイン可変法

ここでは図５の３個の支点２８Ａ〜２８Ｃの駆動部のサーボゲインを速度に応じて可変する方法の一例につき説明する。ウエハの走査速度が$V/\beta$のときの応答周波数を$\nu$とすると、伝達関数Ｇ（ｓ）は以下の様に表される。

$G(s) = 1/(1+Ts)$　（１７）

但し、$T = 1/(2\pi\nu)$、$s = 2\pi f i$、である。

【００６７】解析結果より、走査速度$V/\beta$が８０ｍｍ／ｓの場合、非スキャン方向の応答周波数$\nu$は２Ｈｚが最適で、スキャン方向の応答周波数$\nu$は１０Ｈｚが最適であることが分かった。但し、ウエハの露光面の凸凹をピッチｐの正弦波で表し、ウエハ上の各ショット領域の走査方向の長さを$L_0$とすると、（１７）式中の周波数ｆは次のようになる。

$$f = (V/\beta)/L_0 \cdot (L_0/p) = (V/\beta)/p \qquad (18)$$

従って、走査速度$V/\beta$が変化すると周波数ｆも変化するので、最適な応答周波数$\nu$を新たに求める必要がある。このようにして求めた応答周波数$\nu$よりサーボゲインを決定する。

【００６８】（Ｄ）数値フィルタリング法

ここでウエハの露光面上の凹凸のピッチｐは、ステージ位置に依存した関数なので、フォーカス位置のサンプリングをステージ位置に同期して位置基準で行うと、走査速度$V/\beta$に依存しない制御が可能になる。即ち、位置関数で伝達関数Ｇ（ｓ）と同等のフィルタリング効果を持たせるためには、伝達関数Ｇ（ｓ）を逆フーリエ変換して位置関数Ｆ（ｘ）を求め、この位置関数Ｆ（ｘ）を用いて数値フィルタリングを行う。具体的に応答周波数$\nu$の伝達関数Ｇ（ｓ）の一例を図７（ａ）に示し、それに対応する位置関数Ｆ（ｘ）を図７（ｂ）に示す。但し、数値フィルタリング時は助走スキャン距離をとる必要があり、これを行わない場合は位相遅れが生じる。

【００６９】なお、上述のサーボゲイン可変法及び数値フィルタリング法の内の何れの方法においても、位相遅れとフィルタリング効果とで応答性を管理する。位相遅れ（時間遅れ）とは、図１５（ｃ）の曲線３７Ａで示される目標とするフォーカス位置に対応する信号と、曲線３８Ａで示される実際に計測されたフォーカス位置に対応する信号との間に存在する時間遅れである。フィルタリング効果とは、図１５（ｄ）の曲線３７Ｂ及び３８Ｂで示すように、目標とするフォーカス位置に対して実際のフォーカス位置の振幅を所定量だけ小さくすることである。

【００７０】上述のように、本例ではウエハの各ショット領域への露光を行う際に、予備的な走査である助走スキャンを行う場合がある。そこで、その助走スキャン距離の設定方法について説明する。図８（ａ）は、ウエハ上のショット領域$SA_{11}$の露光を終わってから、順次隣りのショット領域$SA_{12}$及び$SA_{13}$へレチクルのパターンを露光する場合の走査方法を示す。この図８（ａ）において、ウエハを−Ｙ方向に走査して、ウエハ上のショット領域$SA_{11}$への露光が終わってから、加減速期間$T_{11}$の間にウエハをＸ軸及びＹ軸に対して斜めに移動させて、次のショット領域$SA_{12}$の下端の近傍を投影光学系の露光フィールドに配置する。最初のショット領域$SA_{11}$への露光が終わってから、次のショット領域$SA_{12}$の下端の近傍へ移動する間にＹ方向へ間隔ΔＬの移動が行われる。また、その加減速期間$T_{11}$の終期において、ウエハのＹ方向への移動が開始される。

【００７１】その後の制定（整定）期間$T_{W2}$の間に、ウエハの走査速度がほぼＶ／βに達し、それに続く露光期間$T_{W3}$の間にショット領域$SA_{12}$へのレチクルのパターンの露光が行われる。この場合の、ウエハ側での加減速期間$T_{W1}$、制定期間$T_{W2}$及び露光期間$T_{W3}$を図８（ｃ）に示し、レチクル側での加減速期間$T_{R1}$、制定期間$T_{R2}$及び露光期間$T_{R3}$を図８（ｂ）に示す。なお、レチクル側では図８（ａ）のように隣りのショット領域へ移動する必要がないため、レチクル側のステージの移動はＹ軸に沿う往復運動である。また、ウエハ側では、図８（ｃ）に示すように、加減速期間$T_{W1}$から制定期間$T_{W2}$へ移行する程度の時点$t_s$から、多点フォーカス位置検出系によるフォーカス位置のサンプリングが開始される。

【００７２】本例では位相遅れとフィルタリング効果とで、レベリング及びフォーカシング時の応答性を管理するので、ウエハ上でフォーカス位置のサンプリングを開始するときの開始点が、状況によって異なってくる。例えば、サンプリングをステージ位置に同期させるものとして、数値フィルタリングを行うとすると、次の手順でサンプリング開始位置が決定される。

【００７３】先ず、図７（ａ）のように伝達関数Ｇ（ｓ）が与えられ、この伝達関数Ｇ（ｓ）より逆フーリエ変換で図７（ｂ）の位置関数Ｆ（ｘ）を求め、この位置関数Ｆ（ｘ）の原点からゼロクロス点までの長さΔＬを求める。この長さΔＬが、図８（ａ）に示すように、隣りのショット領域$SA_{12}$への露光のために斜めに移動する際のＹ方向への移動量ΔＬと等しい。

【００７４】また、レチクルの加減速期間$T_{R1}$に対して、ウエハの加減速期間$T_{W1}$が小さいため、時間（$T_{R1}-T_{W1}$）はウエハ側の待ち時間となる。この場合、ΔＬ＜（Ｖ／β）（$T_{R1}-T_{W1}$）、のときはスループットの低下にならないが、ΔＬ＞（Ｖ／β）（$T_{R1}-T_{W1}$）、のときはスループットの低下となる。なお、ΔＹ＝ΔＬ－（Ｖ／β）（$T_{R1}-T_{W1}$）、で表される長さΔＹは位相遅れとして処理しても、伝達関数Ｇ（ｓ）と同様のフィルタリング効果が得られれば、固定関数として良い。これらのフィルタリングを行うことにより、多点フォーカス位置検出系に対する空気揺らぎや、多点フォーカス位置検出系の制御誤差の影響を低減する効果も期待できる。

【００７５】次に、本例のスリットスキャン露光方式の投影露光装置における、多点フォーカス位置検出系の計測点中のサンプル点の配置を検討する。先ず、図２（ａ）において、多点フォーカス位置検出系による計測点ＡＦ１１～ＡＦ５９の内で、スリット状の露光フィールド２４内の計測点ＡＦ３１～ＡＦ３９のフォーカス位置の計測結果を用いる場合、即ち計測点ＡＦ３１～ＡＦ３９をサンプル点とする場合には、従来のステッパーの場合と同様の「露光位置制御法」による制御が行われる。更に、本例のウエハのスキャンはＹ方向又は－Ｙ方向へ行われるので、露光フィールド２４に対して走査方向の手前に計測点中のサンプルを配置することで、先読み制御、時分割レベリング計測、及び計測値平均化等が可能になる。

【００７６】先読み制御とは、図２（ａ）にようのウエハを露光フィールド２４に対して－Ｙ方向にスキャンする場合には、走査の手前の計測点ＡＦ４１～ＡＦ４９，ＡＦ５１～ＡＦ５９中からもサンプル点を選択することを意味する。先読み制御を行うことにより、オートフォーカス機構及びオートレベリング機構の伝達関数Ｇ（ｓ）に対して、実際の応答周波数に対する追従誤差は｜１－Ｇ（ｓ）｜となる。但し、この追従誤差には位相遅れとフィルタリング誤差要因とが入っているので、先読み制御を行えば、位相遅れを除去できることになる。この誤差は１－｜Ｇ（ｓ）｜なので、約４倍の伝達能力を持たせる事が出来る。

【００７７】図９（ａ）は従来と同様の露光位置制御を行った場合の目標とするフォーカス位置に対応する曲線３９Ａ及び実際に設定されたフォーカス位置に対応する曲線３８Ｂを示し、図９（ｂ）は先読み制御を行った場合の目標とするフォーカス位置に対応する曲線４０Ａ及び実際に設定されたフォーカス位置に対応する曲線４０Ｂを示し、露光位置制御では位相がずれている。従って、露光位置制御の場合の目標位置と追従位置との差Ｆａは、先読み制御の場合の目標位置と追従位置との差Ｆｂの約４倍となる。従って、先読み制御では約４倍の伝達能力をもたせることができる。

【００７８】しかし、既に述べた様に、オートレベリングの応答周波数はスキャン方向で１０Ｈｚ程度が適当（位置制御法では）なので、先読み制御を行うと、スキャン方向では２．５Ｈｚ程度のフィルタリング応答で良いことになる。このフィルタリングを数値フィルタ又は制御ゲインによって行うと、ウエハの走査速度を８０ｍｍとして、５（≒80/(2π*2.5)）ｍｍ程度の助走スキャン長が、露光前に必要になる。以下に両制御法による、フォーカス誤差を示す。

【００７９】そのため、図１７の場合と同様に、ウエハ上のショット領域$SA_{ij}$のスキャン方向の周期的な曲がりの周期を、スキャン方向の幅との比の値として曲がりパラメータＦで表し、その周期的な曲がりがあるときの各計測点でのフォーカス誤差を、各計測点でのフォーカス位置の誤差の平均値の絶対値と、フォーカス位置の誤差の振幅の１／３との和で表す。また、曲がりパラメータＦの周期的な曲がりの振幅を１に規格化し、曲がりパラメータがＦであるときの、それら各計測点でのフォーカス誤差の内の最大値を示す誤差パラメータＳを、曲がりパラメータＦに対する比率として表す。

【００８０】図１０（ａ）は、露光位置制御を行った場合で、且つスキャン方向のレベリングの応答周波数ｆｍ

が１０Ｈｚ、非スキャン方向のレベリングの応答周波数ｆｎが２Ｈｚの場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ９及びＢ９は共に非スキャン方向での誤差パラメータＳ、曲線Ａ１０及びＢ１０は共にスキャン方向での誤差パラメータＳを示す。一方、図１７（ｂ）は、先読み制御を行った場合で、且つスキャン方向のレベリングの応答周波数ｆｍが２．５Ｈｚ、非スキャン方向のレベリングの応答周波数ｆｎが０．５Ｈｚの場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ１１及びＢ１１は共に非スキャン方向での誤差パラメータＳ、曲線Ａ１２及びＢ１２は共にスキャン方向での誤差パラメータＳを示す。

【００８１】以上の様に先読み制御で位相遅れを除去することは、応答を向上するためには良いが、応答を低下させる場合には適さない。しかし、先読み制御はソフトウェア的に自由度が多く、図１１で示すような時間的平均化及び露光開始時でのフォーカス位置の計測点の予測設定を行うこともできる。即ち、図１１（ａ）において、ウエハの露光面５ａ上の或る領域２６Ｂに対して多点フォーカス位置検出系の走査方向に対して手前のサンプル点（ＡＦ点）において、幅ΔＬの長さだけフォーカス位置が検出される。そして、図１１（ｂ）に示すように、領域２６Ｂが露光点に達したときには、幅ΔＬの範囲で検出されたフォーカス位置の情報を平均化して高精度にレベリング及びフォーカシングが行われる。

【００８２】また、図１１（ｃ）に示すように、露光位置制御法で計測点と露光点とが等しい場合で、ウエハの露光面５ａに段差部２６Ｃがあっても、図１１（ｄ）に示すように、フォーカス対象とする面（フォーカス面）ＡＦＰは次第に上昇するだけで、その段差部２６Ｃではデフォーカスされた状態で露光が行われる。これに対して、図１１（ｅ）に示すように、先読み制御法で計測点と露光点とが離れている場合で、ウエハの露光面５ａに段差部２６Ｄがあると、予めその段差に合わせて図１１（ｆ）に示すように、フォーカス面ＡＦＰを次第に上昇することにより、その段差部２６Ｄでは合焦された状態で露光が行われる。

【００８３】なお、先読み制御法のみならず、通常の露光位置制御法も備えておき、２つの制御法を選択可能なシステムにすることが望ましい。本例のオートフォーカス及びオートレベリング機構には、上述のような機能があるので、実際にウエハの露光面の制御を行うには、①露光位置制御、②完全先読み制御、③分割先読み制御よりなる３種類の制御法が考えられる。以下ではこれら３種類の制御法につき詳細に説明する。

（Ｆ）露光位置制御法

この方式ではオートフォーカス及びオートレベリング機構の応答性能を一切考慮せず、露光時に計測して得られたフォーカス位置の値を用いて、ウエハの露光面のフォーカス位置及びレベリング角の制御を行う。即ち、図１２（ａ）に示すように、露光フィールド２４に対して走査方向（Ｙ方向）に手前側の第２列２５Ｂの偶数番目の計測点をサンプル点４１として、露光フィールド２４内の第３列２５Ｃの奇数番目の計測点をもサンプル点とする。そして、第２列２５Ｂのサンプル点でのフォーカス位置の計測値と第３列２５Ｃのサンプル点でのフォーカス位置の計測値とから、ウエハの露光面のスキャン方向のレベリング制御を行う。

【００８４】また、第２列２５Ｂ及び第３列２５Ｃのサンプル点でのフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求めて、非スキャン方向のレベリング制御を行う。また、フォーカス制御は、露光フィールド２４内の第３列の計測点でのフォーカス位置の計測値も用いてフォーカス制御を行う。なお、図１２（ｂ）に示すように、ウエハのスキャン方向が－Ｙ方向である場合には、サンプル点は第３列２５Ｃ及び第４列２５Ｄの計測点から選択される。この方式では、最も制御が簡単であるが、ウエハのスキャン速度等により追従精度が変わってしまうという不都合がある。また、第２列２５Ｂ及び第３列２５Ｃの各計測点でのフォーカス位置のキャリブレーションが必要である。

【００８５】（Ｇ）完全先読み制御法

この方式では、図１２（ｃ）に示すように、露光フィールド２４に対して走査方向に手前側の第１列２５Ａの全ての計測点をサンプル点として、予め露光前に第１列２５Ａのサンプル点でのフォーカス位置の値を全て計測しておく。そして、平均化処理やフィルタリング処理を行い、位相遅れを見込んで露光時にオープンでオートフォーカス及びオートレベリング機構を制御する。即ち、第１列２５Ａの各サンプル点でのフォーカス位置の計測値を記憶しておき、時間軸上で計測されたフォーカス位置の値からスキャン方向の傾きを算出し、露光時にスキャン方向のレベリング制御をオープン制御で行う。

【００８６】それと並行して、第１列２５Ａの各サンプル点でのフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求め、非スキャン方向のレベリング制御をオープン制御で行う。先読みなので、時間軸での平均化も可能である。また、第１列２５Ａの各サンプル点でのフォーカス位置の計測値を記憶しておき、露光時にフォーカス合わせをオープン制御で行う。なお、図１２（ｄ）に示すように、ウエハの走査方向が－Ｙ方向の場合には、第５列２５Ｅの全ての計測点がサンプル点として選択される。

【００８７】この方式では、第１列２５Ａにおいてサンプル点が９点確保できるため、情報量が多く精度向上が期待できる。また、サンプル点は１ラインなのでキャリブレーションが不要である共に、応答性の管理ができるという利点がある。一方、第１列２５Ａのサンプル点に関してまともに計測を行うと、各ショット領域の端部の露光を行うために走査すべき距離（助走スキャン長）が

長くなり、スループットが低下する不都合がある。また、オープン制御なので、多点フォーカス位置検出系による確認ができないという不都合もある。

【００８８】（Ｈ）分割先読み制御法

この方式では、図１２（ｅ）に示すように、露光フィールド２４に対して走査方向（Ｙ方向）に手前側の第２列２５Ｂの奇数番目の計測点をサンプル点として、露光フィールド２４内の第３列２５Ｃの偶数番目の計測点をもサンプル点とする。そして、第２列２５Ｂ及び第３列２５Ｃのサンプル点において、予め露光前にフォーカス位置の値を全て計測しておく。その後、平均化処理やフィルタリング処理を行い、位相遅れを見込んで露光時にオープン制御で制御を行う。即ち、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値を記憶しておき、時間軸上で計測されたフォーカス位置の値からスキャン方向の傾きを算出し、露光時にスキャン方向のレベリングをオープン制御で行う。

【００８９】また、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求め、非スキャン方向のレベリングをオープン制御で行う。先読みなので、時間軸での平均化も可能である。また、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値を記憶しておき、露光時にフォーカス合わせをオープン制御で行う。なお、図１２（ｆ）に示すように、ウエハのスキャン方向が－Ｙ方向である場合には、サンプル点は第３列２５Ｃ及び第４列２５Ｄの計測点から選択される。

【００９０】この方式では、第２列２５Ｂ（又は第４列２５Ｄ）が露光フィールド２４に近接しているため、ウエハの各ショット領域の端部の露光を行うための助走スキャン距離を少なくできると共に、応答性の管理ができるという利点がある。また、露光時の第３列２５Ｃのサンプル点でのフォーカス位置の計測値から、オープン制御で露光面の制御を行った結果の確認が可能である。一方、第２列２５Ｂのサンプル点でのフォーカス位置と第３列のサンプル点でのフォーカス位置とのキャリブレーションが必要であるという不都合がある。

【００９１】また、完全先読み制御法では、図１３（ａ）～（ｄ）に示すように、露光開始、露光中及び露光終了間際のフォーカス位置のサンプル点を変えることによって、より正確なオートフォーカス及びオートレベリング制御を行っている。即ち、図１３（ａ）に示すように、露光すべきショット領域ＳＡが露光フィールド２４に対して間隔Ｄ（露光フィールド２４のスキャン方向の幅と同じ）の位置に達したときに、露光フィールド２４から間隔Ｄのサンプル領域４２で多点フォーカス位置検出系によるフォーカス位置の計測が開始される。幅Ｄ、即ち露光フィールド２４のスキャン方向の幅の一例は８ｍｍである。その後、図１３（ｂ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に接触したときに、ウエハ上の２個のサンプル点間の検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、１個のサンプル点よりなる検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９２】次に、図１３（ｃ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に入ったときに、ウエハ上の２個のサンプル点間の検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、２個のサンプル点間の検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。また、図１３（ｄ）に示すように、ショット領域ＳＡが露光フィールド２４を覆うようになったときには、露光フィールド２４を覆う検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、露光フィールド２４を覆う検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９３】一方、分割先読み制御法でも、図１３（ｅ）～（ｈ）に示すように、露光開始、露光中及び露光終了間際のフォーカス位置のサンプル点を変えることによって、より正確なオートフォーカス及びオートレベリング制御を行っている。即ち、図１３（ｅ）に示すように、露光すべきショット領域ＳＡが露光フィールド２４に対して間隔Ｄ／２（露光フィールド２４のスキャン方向の幅の１／２）の位置に達したときに、露光フィールド２４から外側に間隔Ｄ／２のサンプル領域４３Ａ及び露光フィールド２４から内側に間隔Ｄ／２のサンプル領域４３Ｂで多点フォーカス位置検出系によるフォーカス位置の計測が開始される。その後、図１３（ｆ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に接触したときに、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、１個のサンプル点よりなる検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９４】次に、図１３（ｇ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に幅Ｄ／２だけ入ったときに、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、幅Ｄ／２の検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。また、図１３（ｈ）に示すように、ショット領域ＳＡが露光フィールド２４を覆うようになったときには、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、露光フィールド２４を覆う検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。図１３より、分割先読み法では、助

走スキャン長（＝Ｄ／２）を完全先読み法に比べて１／２にできることが分かる。

【００９５】なお、上述実施例においては、ウエハの露光面の多点のフォーカス位置を計測するために、２次元的に配列されたスリット状の開口パターン像をウエハ上に投影する多点フォーカス位置検出系が使用されている。しかしながら、その代わりに、非スキャン方向に細長いスリット状になっているパターンの像をウエハ上に投影し、その非スキャン方向の全体のフォーカス位置を計測する１次元のフォーカス位置検出系を使用しても良い。また、画像処理方式のフォーカス位置検出系を用いて、ウエハの露光面上の２次元的なフォーカス位置の分布を計測する場合でも、上述実施例と同様の分割先読み等を適用することにより、高精度なフォーカシング及びレベリングを行うことができる。更に、本例では図１７より分かるように、非スキャン方向のレベリング誤差に対して、スキャン方向のレベリング誤差が小さいことから、スキャン方向のレベリング動作を行うことなく、非スキャン方向のみのレベリング動作を行っても良い。

【００９６】なお、本発明は上述実施例に限定されず、本発明の要旨を逸脱しない範囲で種々の構成を取り得ることは勿論である。

【００９７】

【発明の効果】本発明の第１の面位置設定装置によれば、スリットスキャン露光方式の投影露光装置において、感光基板の表面の凹凸、多点計測手段の計測精度、空気揺らぎ等による誤差を補正して、感光基板の露光面を投影光学系の像面に対して高精度に平行に合わせることができる利点がある。

【００９８】また、多点計測手段が、基板側ステージを介して感光基板が走査されているときに、基板側ステージの位置基準で複数の計測点における感光基板の高さをサンプリングする場合には、より高精度に走査方向の傾斜角を計測できる。また、多点計測手段が、所定形状の照明領域と投影光学系に関して共役な露光領域内の複数の点及びその共役な露光領域内に対して感光基板が走査される際の手前の領域内の複数の点よりなる複数の計測点において、その感光基板の高さをそれぞれ計測する場合には、分割先読み制御により、露光の開始時の助走スキャン距離を短縮できる利点がある。

【００９９】また、多点計測手段が、感光基板の１つのショット領域へ順次マスクのパターンを露光する過程において、順次複数の計測点の位置を変化させる場合には、例えば分割先読みと完全先読みとを併用することにより、レベリング精度及びスループットを共に改善することができる。また、本発明の第２の面位置設定装置によれば、スリットスキャン露光方式の投影露光装置において、感光基板の表面の凹凸、多点計測手段の計測精度、空気揺らぎ等による誤差を補正して、感光基板の露光面のフォーカス位置を投影光学系の像面に対して正確



に合わせることができる利点がある。

【図面の簡単な説明】

【図１】本発明による面位置設定装置の一実施例が適用された投影露光装置を示す構成図である。

【図２】（ａ）は実施例において投影光学系による露光フィールドを含む領域に投影された２次元的なスリット状の開口パターン像を示す平面図、（ｂ）は多点フォーカス位置検出系のパターン形成板上の開口パターンを示す図、（ｃ）は受光器上の受光素子の配列を示す図である。

【図３】（ａ）は実施例で分割先読みを行う場合のサンプル点を示す図、（ｂ）は逆方向にスキャンする場合で且つ分割先読みを行う場合のサンプル点を示す図である。

【図４】（ａ）はフォーカス位置を先読みする場合を示す図、（ｂ）は先読みしたフォーカス位置を用いて露光を行う場合を示す図である。

【図５】実施例のオートフォーカス及びオートレベリング機構並びにその制御部を示す構成図である。

【図６】フォーカス位置の計測値の補正方法の説明図である。

【図７】（ａ）は応答周波数νが１０Ｈｚの場合の伝達関数を示す図、（ｂ）は図７（ａ）の伝達関数を逆フーリエ変換して得られた位置関数を示す図である。

【図８】（ａ）は隣接するショット領域へ露光を行う場合のウエハの軌跡を示す図、（ｂ）はレチクルの走査時のタイミングチャート、（ｃ）はウエハの走査時のタイミングチャートである。

【図９】（ａ）は露光位置制御法でレベリング及びフォーカシングを行う場合の追従精度を示す図、（ｂ）は先読み制御法でレベリング及びフォーカシングを行う場合の追従精度を示す図である。

【図１０】（ａ）は露光位置制御法を使用した場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図、（ｂ）は先読み制御法を使用した場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図である。

【図１１】（ａ）及び（ｂ）は先読み制御法における平均化効果の説明図、（ｃ）及び（ｄ）は露光位置制御を行う場合のフォーカス面を示す図、（ｅ）及び（ｆ）は先読み制御を行う場合のフォーカス面を示す図である。

【図１２】（ａ）及び（ｂ）は露光位置制御を行う場合のフォーカス位置のサンプル点を示す平面図、（ｃ）及び（ｄ）は完全先読み制御を行う場合のフォーカス位置のサンプル点を示す平面図、（ｅ）及び（ｆ）は分割先読み制御を行う場合のフォーカス位置のサンプル点を示す平面図である。

【図１３】（ａ）～（ｄ）は完全先読み制御法で露光を行う場合の制御法の説明図、（ｅ）～（ｈ）は分割先読み制御法で露光を行う場合の制御法の説明図である。

【図１４】（ａ）は一括露光を行う場合のフォーカス誤差を示す図、（ｂ）はスリットスキャン露光方式で露光を行う場合のフォーカス誤差を示す図である。

【図１５】（ａ）は計測値の最大値と最小値とを用いてオートフォーカス制御を行う場合のフォーカス誤差を示す図、（ｂ）は計測値の平均値を用いてオートフォーカスを行う場合のフォーカス誤差を示す図、（ｃ）は時間遅れ誤差を示す図、（ｄ）はサーボゲインの変化を示す図である。

【図１６】スリット状の露光フィールドでウエハ上のショット領域への露光を行う状態を示す平面図である。

【図１７】（ａ）はスキャン方向の応答周波数と非スキャン方向の応答周波数とを等しくしてレベリング制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図、（ｂ）はスキャン方向の応答周波数を非スキャン方向の応答周波数より高くしてレベリング制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図である。

【図１８】（ａ）はフォーカス位置の平均値を用いてオートフォーカス制御を行う状態を示す図、（ｂ）はフォーカス位置の最大値及び最小値の平均値を用いてオートフォーカス制御を行う状態を示す図である。

【図１９】（ａ）は図１７（ａ）の状態において更に平均化処理でオートフォーカス制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図、（ｂ）は図１７（ｂ）の状態において更にフォーカス位置の最大値及び最小値の平均値を用いてオートフォーカス制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図である。

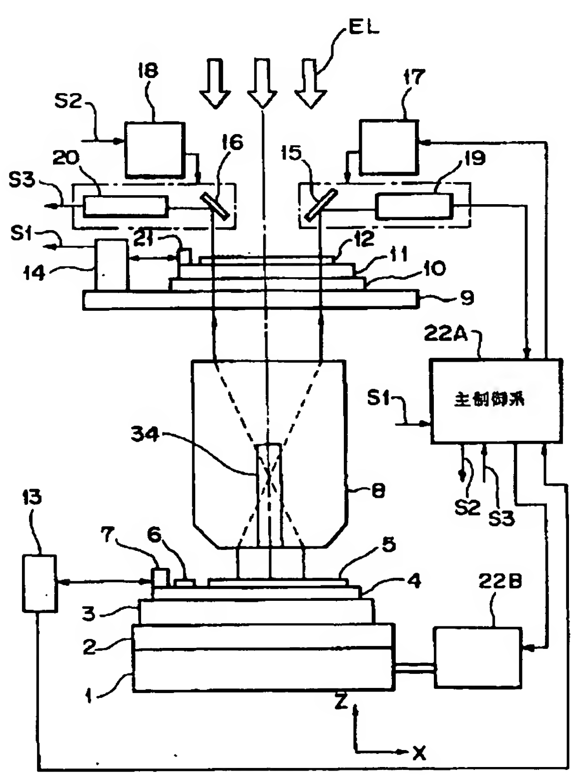
【図２０】従来のステッパーにおける多点フォーカス位置検出系を示す構成図である。

【図２１】（ａ）は図２０において投影光学系による露光フィールドを含む領域に投影された２次元的なスリット状の開口パターン像を示す平面図、（ｂ）は図２０の多点フォーカス位置検出系のパターン形成板上の開口パターンを示す図、（ｃ）は図２０の受光器上の受光素子の配列を示す図である。

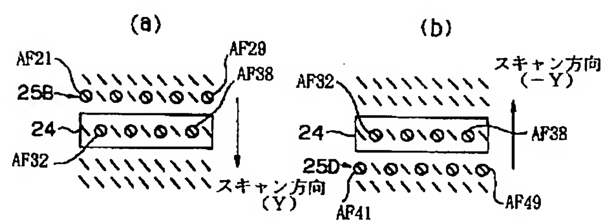
【符号の説明】

２　ウエハＹ軸駆動ステージ
４　Ｚレベリングステージ
５　ウエハ
８　投影光学系
１０　レチクルＹ駆動ステージ
１２　レチクル
２２Ａ　主制御系
２４　スリット状の露光フィールド
６２Ａ　パターン形成板
６９Ａ　受光器
７１Ａ　信号処理装置
ＡＦ１１～ＡＦ５９　計測点

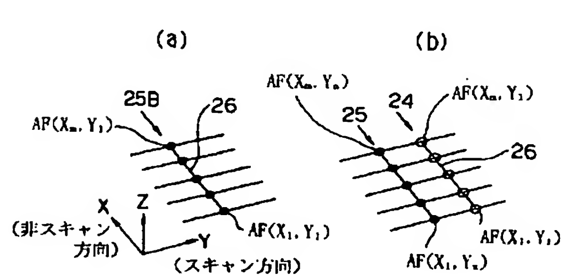
【図１】



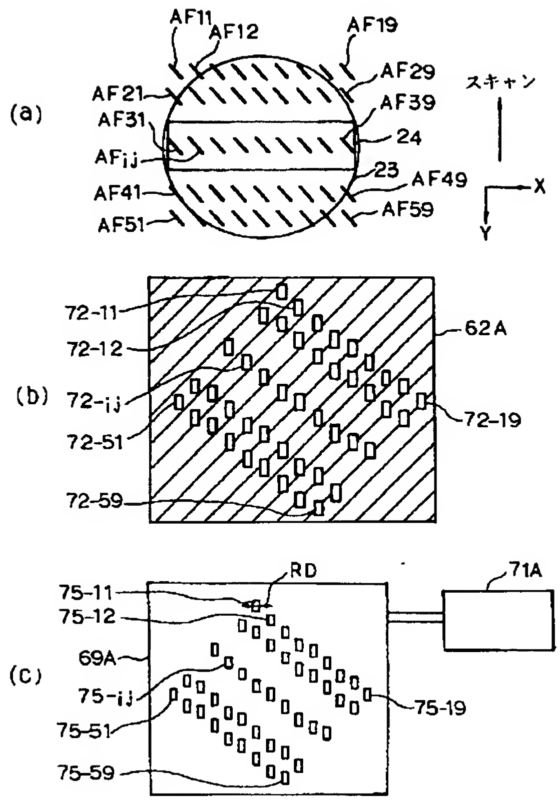

【図３】



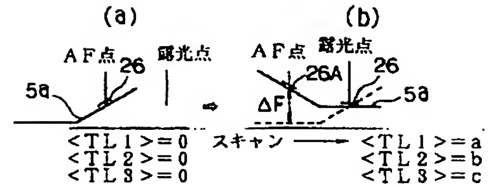

【図４】



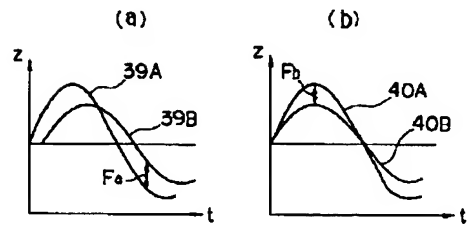
【図2】



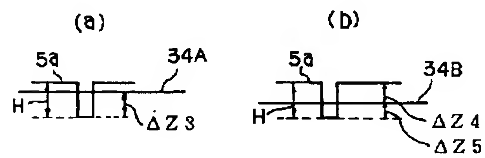

【図6】



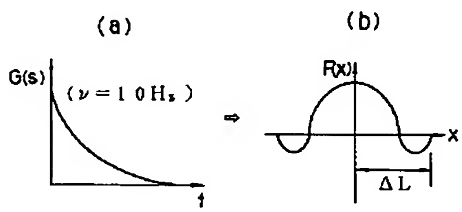

【図9】



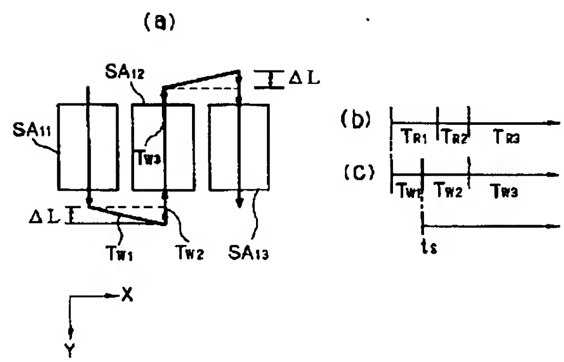

【図18】



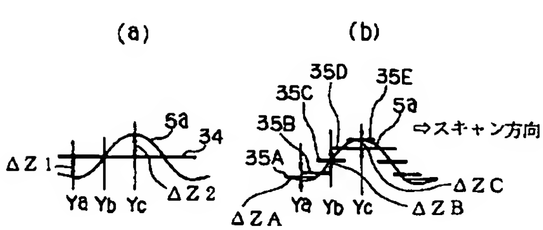

【図7】



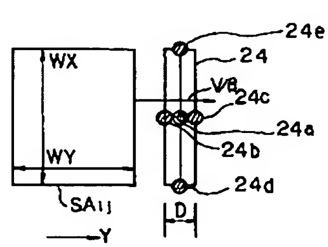

【図8】



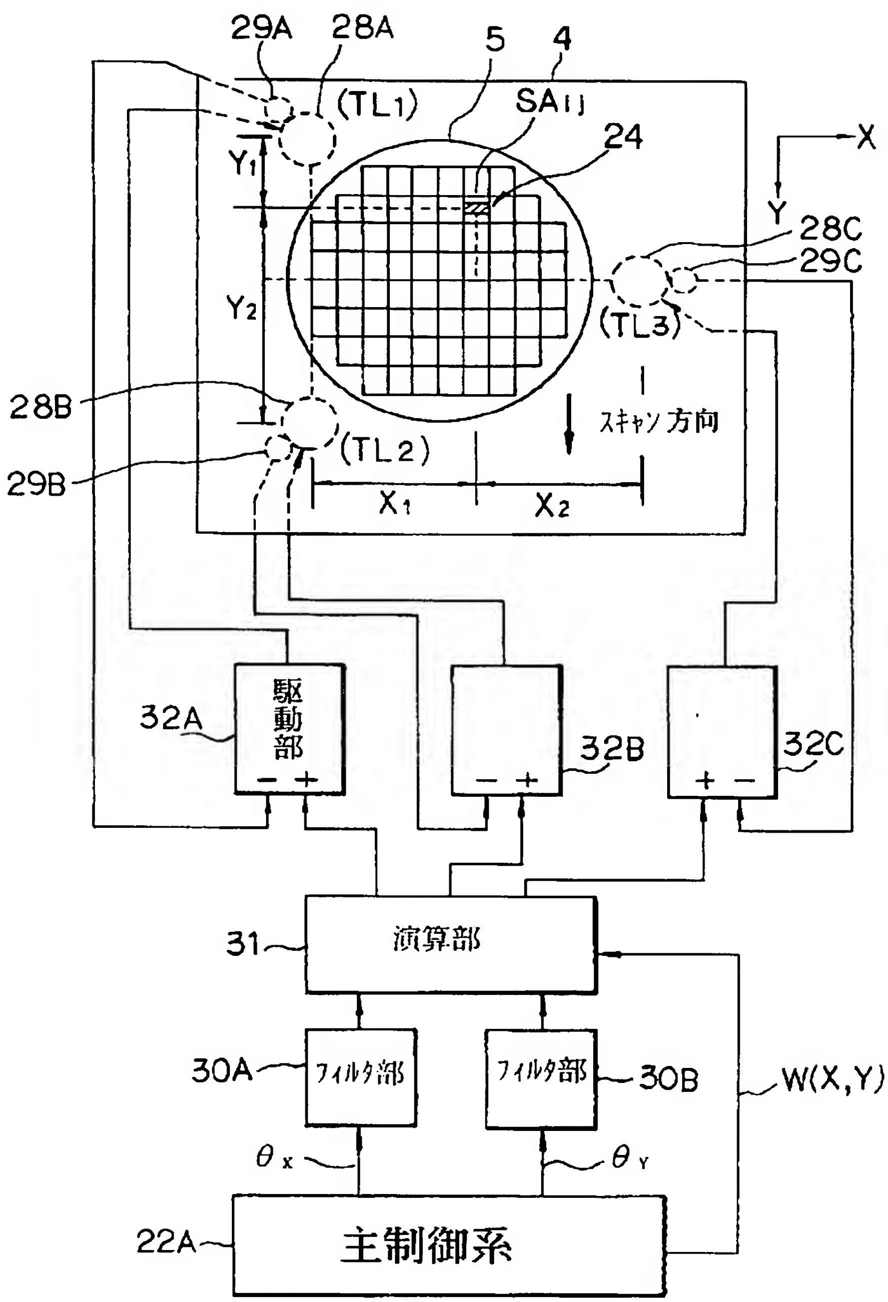

【図14】



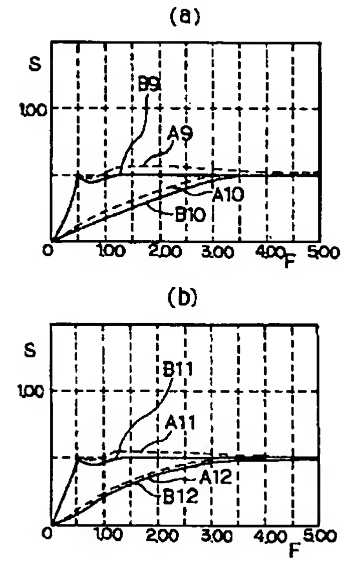

【図16】



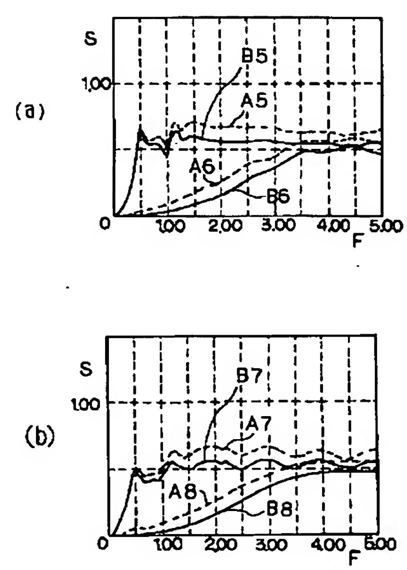
【図5】


29A
28A
5
4
(TL1)
SAij
24
X
Y
28C
29C
Y1
Y2
(TL3)
28B
29B
(TL2)
スキャン方向
X1
X2
32A
駆動部
− +
32B
− +
32C
+ −
31
演算部
30A
フィルタ部
フィルタ部
30B
W(X,Y)
θx
θY
22A
主制御系

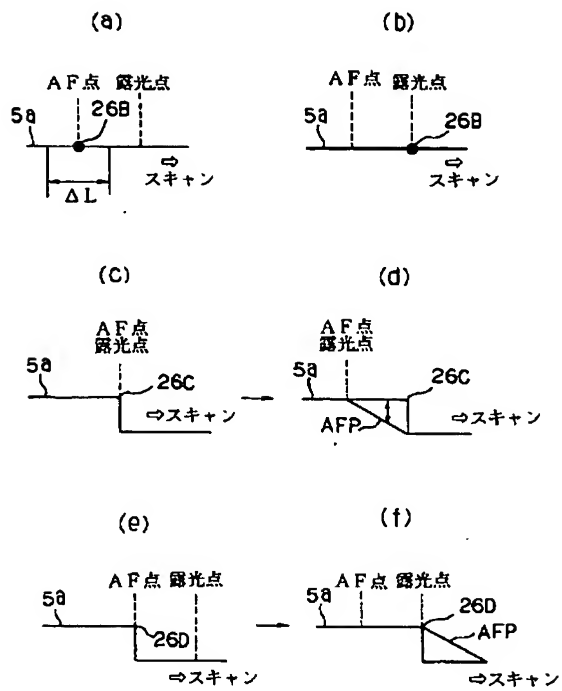
【図10】


(a)
S
1.00
B9
A9
A10
B10
0
1.00
2.00
3.00
4.00
5.00
F
(b)
S
1.00
B11
A11
A12
B12
0
1.00
2.00
3.00
4.00
5.00
F

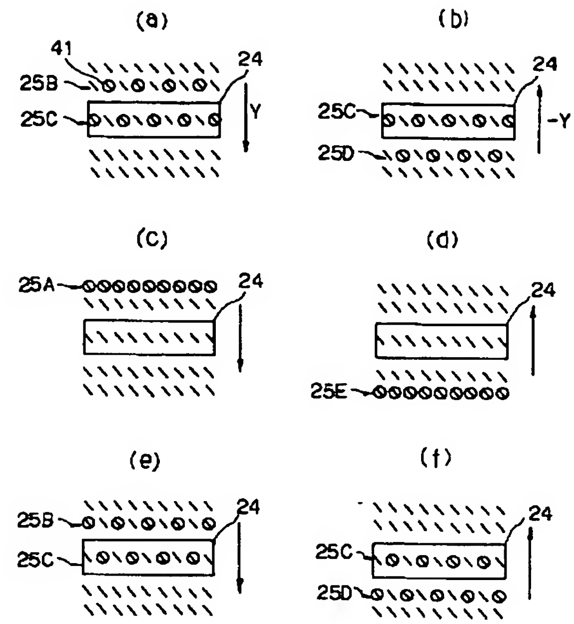
【図19】


(a)
S
1.00
B5
A5
A6
B6
0
1.00
2.00
3.00
4.00
5.00
F
(b)
S
1.00
B7
A7
A8
B8
0
1.00
2.00
3.00
4.00
5.00
F

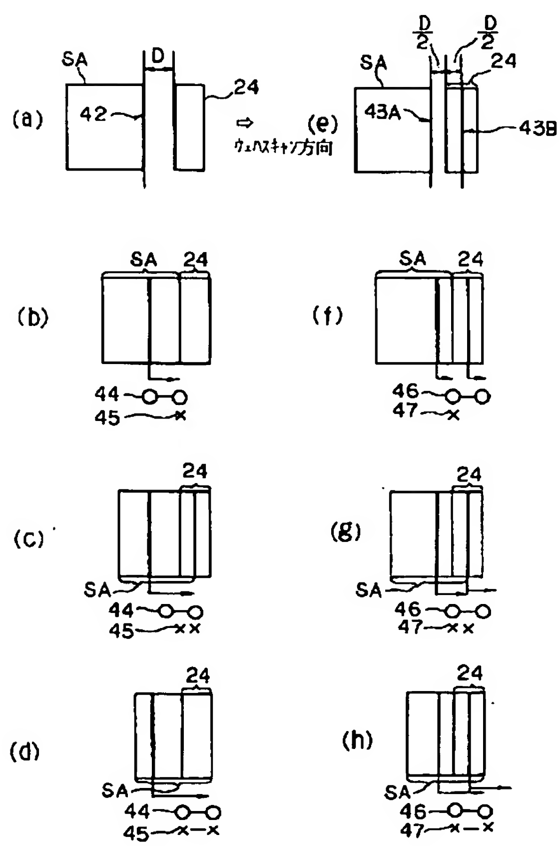
【図１１】



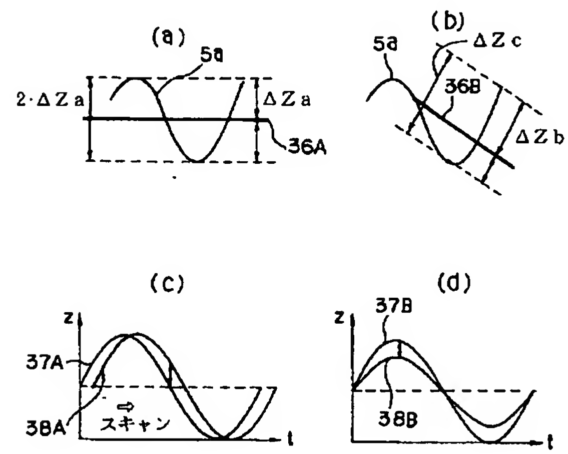

【図１２】



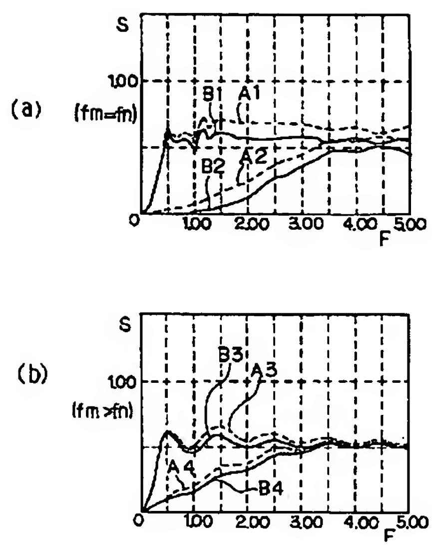

【図１３】



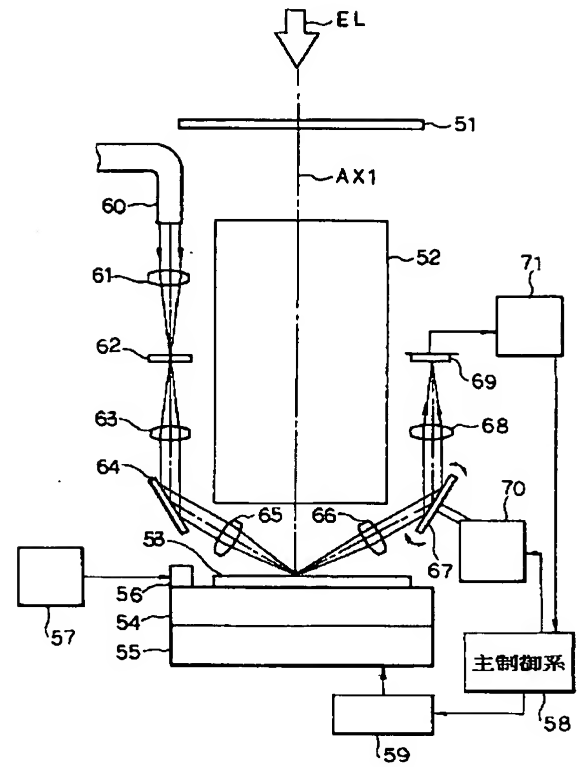

【図１５】



【図１７】

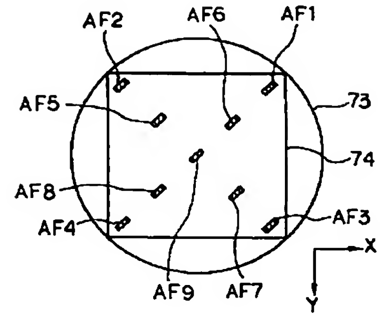

(a)
S
1.00
(fm=fn)
B1
A1
B2
A2
0
1.00
2.00
3.00
4.00
5.00
F
(b)
S
1.00
(fm>fn)
B3
A3
A4
B4
0
1.00
2.00
3.00
4.00
5.00
F

【図２０】

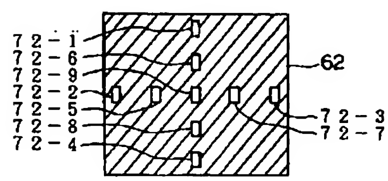

EL
51
AX1
60
52
61
71
62
69
63
68
64
70
65
66
53
67
56
57
54
55
主制御系
58
59

【図２１】

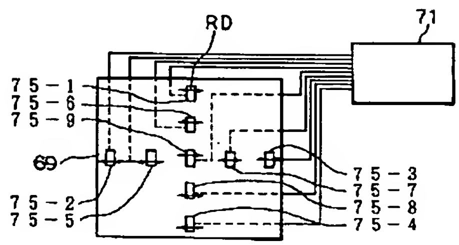
(a)


AF2
AF6
AF1
AF5
73
74
AF8
AF4
AF3
X
Y
AF9
AF7

(b)


72－1
72－6
72－9
72－2
72－5
72－8
72－4
62
72－3
72－7

(c)


RD
71
75－1
75－6
75－9
69
75－2
75－5
75－3
75－7
75－8
75－4